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NORTH SHORE IMPROVEMENT ASSOCIATION.

1902.

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NORTH SHORE IMPROVEMENT ASSOCIATION.

REPORTS ON PLANS

FOR THE

EXTERMINATION OF MOSQUITOES

ON THE

NORTH SHORE OF LONG ISLAND

BETWEEN

HEMPSTEAD HARBOR AND COLD SPRING HARBOR.

THE NEW YORK

1902.

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THE OBJECTS of the North Shore Improvement Association are to secure co-operation in movements for good roads, protecting the water front, preventing and abating nuisances, securing capable and effective town government, and generally promoting such measures as will tend to protect the territory as a desirable residential region.

A Review of the Reports and Plans by Dr. L. O. Howard, Permanent Secretary of American Association for the Advancement of Science.

United States Department of Agriculture,
Division of Entomology,
L. O. Howard, Chief.

Washington, D. C., February 4, 1902.

Dear Mr. Cravath:

I have returned to Washington, and have examined the typewritten Report of your Executive Committee and the galley proofs of the reports submitted by the persons engaged last summer upon your very important work in redeeming from the mosquito pest the territory covered by the North Shore Improvement Association. I congratulate you and the other members of your committee upon the excellent character of the work which has been done, and upon the admirable quality of the reports. They have been written by men who are excellently fitted for the work, and they have been drafted in a most clear-headed and practical manner. Taken as a whole, they indicate in a beautiful way what should be done as preliminary work before attempting to rid any large community or any large section of country of mosquitoes. The problems which they have had to face seem to me to have been especially difficult, and the fact that they have been able to plan such excellent methods of surmounting these difficulties cannot fail to be greeted with enthusiasm by persons residing in other localities where mosquitoes prevail but where the remedial problem is not so difficult. The weight of Professor Shaler's authority, the experience and clear-headedness of Mr. Weeks, and the biological knowledge of Professor Davenport and Mr. Lutz form a rare combination, upon the choice of which your committee is heartily to be congratulated.

There are certain comments which I wish to make upon certain of the statements which occur in these reports, and this I shall do as briefly as possible.

I am greatly interested in the arguments which are advanced against the truthfulness of the prevalent idea that the North Shore suffers from mosquitoes blown up from the South Shore. These arguments, as stated in your executive report and in the reports of Mr. Weeks and Mr. Lutz, seem almost convincing to me, and as a matter of fact, even if we were to admit that mosquitoes may under certain conditions be wafted gently along by light and continuous southerly breezes, your extermination work in your actual territory will be found to have been well worth while. Such southern mosquitoes, in my opinion, can never be a factor of great importance in your local mosquito supply. It is safe, in my

opinion, to put it down as a cardinal principle in this sort of work that most people are responsible for their own mosquitoes.

The fact that *C. sollicitans* has been found to breed in salt water does not obviate the force of the second suggestion in your Executive Committee report regarding the measures of relief. You state, "(b) Keep them (salt marshes) covered with salt water." By this I assume that you mean to allow free entrance of the daily tide and with this the free entrance of fishes which destroy mosquito larvae. Wherever there is a free daily entrance of the salt water at high tide mosquitoes will not be found to breed in any abundance, if at all.

In regard to the maintenance of fish ponds, I wish to call your attention to the fact that it has been shown during the past Summer by Mr. William Lyman Underwood, of the Massachusetts Institute of Technology, and by my own assistants in Washington during my absence in Mexico, that the common gold fish, so abundantly used in aquaria, are voracious mosquito feeders. It has been found that in aquaria they prefer mosquito larvae to the prepared gold fish food. This fact is mentioned since it is so easy to buy gold fish anywhere, and some difficulty may be experienced in securing specimens of the other fish mentioned in your report and also in the section relating to this subject in my book.

In speaking of the desirability of covering rain-barrels, tanks, cisterns, cesspools, drains and catch-basins, you have not in your Report of the Executive Committee sufficiently emphasized the absolute necessity of a tight covering. In one town which I visited last year I was assured that the mosquitoes must breed entirely in the swamps about the town, and that cesspool breeding was out of the question, because all cesspools were covered with stone slabs cemented down. I found, upon examination, that the mosquito supply came almost wholly from these cesspools. The coverings were not tight, and an insignificant crack or a place where the mortar had broken away would allow the entrance of fertile females and the subsequent egress of hordes of freshly issued and hungry mosquitoes.

It is my experience, and the experince of entomologists who have been studying the question carefully the past summer, that mosquito larvae are not found in ponds where the surface is sufficiently extended to admit of a considerable rippling by the winds, except at the margins. Where there are grassy or very low margins, and where water plants exist in any numbers, there mosquitoes will breed in the largest ponds; but that it is perfectly possible to keep a mill-pond entirely free from mosquito larvae by careful treatment of the pond edges, is a fact which has been definitely proved during the past Summer in a locality known to me. Old, uncared-for mill-ponds with marshy borders, with swamp areas depending upon the damming of a stream, with water-plants growing and dead trees here and there, are of course mosquito breeders to a greater or lesser extent. But a dam in constant use, with a daily inflow and outflow of water, with its margins kept clean, is not a dangerous body of water. And it is necessary that this point should be emphasized, since great and unnecessary hardship will unquestionably

ensue if the impression is allowed to prevail that mill-dams *per se* are injurious to health.

I have nothing further to add except once more to congratulate you upon the public-spirited movement which you are inaugurating, and upon the well-planned and forcible measures already undertaken. You are also to be congratulated and thanked for the publication of these reports, on account of their great value to the persons who may undertake similar work in the near future.

Yours very truly,

L. O. Howard.

Mr. Paul D. Cravath,
40 Wall Street,
New York.

NORTH SHORE IMPROVEMENT ASSOCIATION.

REPORTS WITH MAP.

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REPORT OF THE EXECUTIVE COMMITTEE.

I.

ORIGIN OF THE WORK.

During the past three years the subject of ridding communities of the mosquito nuisance has been widely discussed by scientists, physicians, and sanitary experts in this and other countries. More has been learned during the past five years regarding the nature and habits of mosquitoes, and of the possible means of exterminating them, than during the previous hundred years. The discovery, only recently confirmed by proof that may be accepted as final, that the *Anopheles* mosquito is responsible for the dissemination of malaria—a disease which perhaps affects more human beings than any other single disease or group of diseases—has made the mosquito question one of the most important sanitary questions of the day. The subject has been brought to the attention of the residents of the North Shore of Long Island with special force, because one of the first and most important practical demonstrations of the feasibility of the plans proposed for exterminating mosquitoes was made at Lloyd's Neck, on Cold Spring Harbor, in the summer of 1900, by Mr. W. J. Matheson, under the direction of Prof. L. O. Howard, Chief of the Division of Entomology of the United States Department of Agriculture. It was there demonstrated in a single season that a locality previously infested by mosquitoes to an unusual degree could be almost entirely freed of the pest by measures at once simple and inexpensive. Similar measures were applied the following summer on Center Island, and while the circumstances attending the work there were such that complete success in a single season could not be expected, the results were in the highest degree encourag-

ing. (See Appendix III.) The Executive Committee of the North Shore Improvement Association accordingly determined that they could in no way more effectively advance the Association's policy of devising measures calculated to benefit the entire community than by inaugurating a plan for eliminating or minimizing the mosquito nuisance in the territory covered by the Association's activities. The importance of this work was accentuated last summer by the unusual number of mosquitoes and by the general belief that the nuisance is on the increase. The work which the Committee undertook to do last fall was the examination by competent experts of the territory extending from Roslyn to Cold Spring, inclusive, and from the Sound to the high range of hills which form the backbone of the island.

II.

MANNER OF CONDUCTING THE EXAMINATION.

The work was entrusted to Mr. Henry Clay Weeks, who, having had charge of the successful experiments on Lloyd's Neck and Center Island, had the advantage of more practical experience than any other engineer. Associated with him as entomologists were Prof. Charles B. Davenport, Professor of Entomology at the University of Chicago and head of the Cold Spring Biological Laboratory, and Mr. F. E. Lutz, an instructor in Biology at the University of Chicago. Prof. N. S. Shaler, Dean of the Lawrence Scientific School, of Harvard University, and the most eminent authority in this country on marine marshes, was retained to make a special examination of the salt marshes with a view to recommending the best means of eliminating them as the most prolific breeding grounds of mosquitoes. Prof. Davenport and Mr. Lutz and their assistants made a detailed examination of the entire territory, and located, as nearly as possible, every breeding place of mosquitoes, including the smaller pools and streams, and even the various artificial receptacles of water. Their detailed reports were delivered to Mr. Weeks, who, with his assistant, examined each body of water in which mos-

quito larvæ had been found, with a view to devising the best means of preventing the further breeding of mosquitoes therein. In his report will be found not only a recommendation as to the best means of treating each breeding place, but a careful statement of the cost of carrying out each recommendation.

A map of the entire territory has been prepared, on which is located every natural breeding place of mosquitoes reported upon by the entomologists and the engineer, so that any resident of the territory can, by examining this map and the reports of Mr. Weeks, Prof. Davenport and Mr. Lutz, ascertain the sources of mosquitoes upon his property or in his immediate neighborhood and the precise means recommended for affording relief to himself and his neighbors.

All the reports were submitted to Prof. Howard, the head of the Entomological Division of the Department of Agriculture at Washington, the most eminent authority in this country on mosquitoes and measures for their destruction, who manifested his interest in the work by an instructive report.

III.

A SUMMARY OF THE IMPORTANT CONCLUSIONS BELIEVED BY THE COMMITTEE TO BE ESTABLISHED BY THE REPORTS OF THE ENGINEER AND THE ENTOMOLOGISTS.

While much still remains to be learned of the habits of the mosquito and the best means of abating the mosquito nuisance, the Committee feel that certain conclusions may be accepted as established.

1. *Mosquitoes breed chiefly in stagnant or slowly moving fresh or brackish water.* That mosquitoes breed only in water is established beyond dispute. They never breed in the air or in bushes or in damp places, as is commonly supposed. There must be a distinct accumulation of water. While they do not breed in rapidly moving water, they breed to an appreciable extent in clear water. Indeed, the favorite breeding place of the *Anopheles* mos-

quito seems to be in the clear water of sluggish pools and streams, and even springs.

2. *Salt marshes as breeding grounds for mosquitoes.* Mosquitoes rarely breed in salt water. Accordingly, mosquitoes are not produced in salt marshes which are covered by salt water at every tide. While salt marshes are the most productive sources of mosquitoes, the breeding takes place principally in the pools of water left by the high monthly tides, which, not being reached by the intermediate tides, become brackish. If the accumulation of these brackish pools on a salt marsh can be prevented, it will cease to be a breeding place for mosquitoes.

3. *The importance of the difference between the Culex and the Anopheles mosquito.* The *Anopheles* is the only mosquito which transmits human malaria. The *Culex* is entirely harmless so far as the transmission of malaria is concerned. The *Culex* is many times more abundant than the *Anopheles*. Probably only a fraction of one per cent. of the mosquitoes on the North Shore of Long Island are *Anopheles*. It is the *Culex* which breeds in such numbers in the brackish pools around the salt marshes. The *Anopheles* rarely breeds in brackish water, but will breed in contaminated fresh water and principally in clear water such as is found in ponds, pools, springs, and accumulations of water in the neighborhood of springs. It is principally *Culex* which are bred in the numerous accumulations of rain-water, such as cisterns, rain-barrels, etc. In many localities where *Culex* are abundant, few *Anopheles* are bred, as, for instance, Bayville.

4. *The connection between the Anopheles mosquito and malaria.* It is now a settled fact that malaria is rarely, if ever, communicated to human beings except through the medium of the *Anopheles* mosquito. If there are exceptions to this rule they have not been discovered by investigators and are so rare as to be unimportant. Probably every person who suffers from true malaria, in any form, received the infection from the bite of an *Anopheles* mosquito which had bitten some other human

being infected with malaria, because it is probable that so far as transmitting malaria is concerned, the *Anopheles* mosquito is as innocent as the *Culex* until it has taken into its system human blood containing the malarial germ. Malaria as a prevalent disease does not exist in communities where there are no *Anopheles* mosquitoes, and if any community in which *Anopheles* mosquitoes are found can be rid of them, malaria will disappear as certainly as night follows day.

5. *Mosquitoes which trouble the north shore of Long Island are bred at home, and do not come from the south side.* The old theory that the south side supplied a large proportion of the mosquitoes which infested the north shore of Long Island has been exploded. If any mosquitoes come from so great a distance, they come so rarely and in such small numbers as not to appreciably affect the situation. Mosquitoes, as a rule, do not travel far from their breeding places. Nor are they, except under exceptional circumstances, carried far by winds. They are less likely to be carried any great distance by wind over land than over water, because on land they seek refuge from the wind in trees and bushes. Any observer knows that even in districts in which mosquitoes are abundant, they are rarely in evidence in a strong breeze, and that it is only when the breeze dies down that they come from their hiding places. The soundness of this theory is also demonstrated by the comparative immunity from mosquitoes which certain districts enjoy, although surrounded by territory infested with mosquitoes. For instance, Sea Cliff, which is upon a high plateau containing few accumulations of fresh or brackish water in the immediate neighborhood, has few mosquitoes, although they are bred in abundance on the opposite side of Hempstead Harbor and in the salt marshes of Mosquito Cove in the neighborhood of the starch works, and in various localities in the direction of Roslyn.

Fortunately, the *Anopheles* mosquito is even less migratory than the *Culex*. While the *Culex*, except under exceptional conditions, is not carried more than a mile, or at the utmost two miles, from its breeding place, *Anopheles* mosquitoes are rarely found more than a few hundred

feet from their breeding place, and they rarely fly in the daytime. This is why malaria is so closely confined to the immediate neighborhood of the breeding places of the *Anopheles* mosquito. This explains why Bayville, although infested with *Culex* mosquitoes from the salt marshes, is practically free from malaria. It is almost entirely free from the fresh water pools in which *Anopheles* breed. It accordingly follows that if the breeding of mosquitoes can be prevented or materially reduced in the territory in which we are immediately interested, the desired relief will be secured however abundant mosquitoes may continue to be on the south shore, or in other neighboring territory.

6. *It is possible to practically rid our region of mosquitoes.* It is not proposed that any attempt be made to kill adult mosquitoes. The plan is to prevent them from breeding, or destroy their larvæ where the breeding places cannot be disposed of. Fortunately, the life of the mosquito is short, so that if breeding of mosquitoes can be prevented, the supply of adult mosquitoes will soon disappear. As mosquitoes are bred in fresh or brackish water, and pass through the larval stage as "wigglers," it is only against such accumulations of water that the measures of relief need be directed.

IV.

MEASURES OF RELIEF AGAINST MOSQUITOES THE PRACTICABILITY AND EFFICIENCY OF WHICH HAVE BEEN DEMONSTRATED.

1. *The elimination of many troublesome breeding places by drainage and filling.* There are a great many entirely useless accumulations of water which should be removed either by filling or draining.

2. *Salt Marshes.* The problem in the case of salt marshes is to either (a) drain them, (b) keep them covered with salt water, or (c) so treat them as to prevent accumulations of brackish water between extreme tides. That every marsh in our region can be disposed of in one of these ways is demonstrated by Prof. Shaler's report.

Many of the marshes can be diked and drained and subjected to cultivation, with the result that the increased value of the land will partially, and in some cases entirely, repay the cost of diking and draining. Other meadows, differently situated, can be advantageously kept flooded by tidal salt water ponds, as in the case of Dosoris Pond. The third and simplest method of treatment is to fill up the small holes in which the water accumulates between tides, and regulate the banks of the tidal streams so that after the marsh has been flooded by a high tide no accumulations of water will remain long enough to permit the water to become brackish. The problem of treating in one of the three ways above mentioned all of the salt marshes from Lloyd's Neck to Sand's Point is by no means a simple one; but time and patience should solve it. In the meantime we have the assurance that the salt marshes do not produce the malarial mosquito, and that the *Culex* mosquitoes which they produce in such abundance will not, as a rule, be carried back upon the adjoining hills because of their indisposition to travel far, especially against winds from the southwest which prevail in summer.

3. *Streams.* The breeding of mosquitoes in streams can as a rule be prevented by straightening out their banks and so regulating their courses that there are no pools of stagnant or slowly moving water. In some instances, this work would have to be supplemented by piping or ditching.

4. *Springs.* The breeding of mosquitoes in springs can usually be corrected by confining the spring to definite banks by simple expedients known to every farmer. Areas of "springy" ground, containing numerous small accumulations of spring water, should be drained or filled.

5. *Ponds and bodies of water which cannot be drained or filled.* In such cases the breeding of mosquitoes will be greatly reduced, if not prevented, by making the edges of the pond regular and freeing them from vegetation so that there will be no accumulations of shallow water which are not accessible to fish. The maintenance of cer-

tain kinds of fish, such as goldfish, sunfish, sticklebacks and top minnows in ponds so treated would probably entirely prevent breeding of mosquitoes or prevent them from breeding to any serious extent. In rare instances, where no other treatment is possible, relief can be had by the periodical use of petroleum.

6. *Rain-barrels, tanks, cisterns, etc.* The breeding of mosquitoes in these fertile breeding places can readily be prevented by the exercise of care on the part of householders and of reasonable vigilance on the part of the public authorities. Rain-barrels and tanks should be kept covered and the water should be drawn from the bottom by spigots. Mosquitoes will not breed in cisterns if they are kept covered, especially if a few fish are introduced.

7. *Cesspools, drains, catch-basins, etc.* They should be kept covered as far as possible, and where it is not practicable to cover them the breeding of mosquitoes can be prevented by the use of petroleum.

V.

THE NECESSITY FOR COOPERATION ON THE PART OF PUBLIC OFFICIALS.

A large proportion of the citizens, when once their interest has been aroused, will voluntarily take the necessary action, so far as their own premises are concerned, to abate the mosquito nuisance. The relief, however, will not become general without the cooperation of the public authorities. In view of the extent to which the health and comfort of the community are dependent upon the abatement of the mosquito nuisance, the enforcement of the necessary measures to this end is clearly within the province of the public authorities. Proper regulations should be enacted by the boards of health and should be enforced by official inspectors.

VI.

NECESSITY FOR FURTHER LEGISLATION.

No comprehensive plan for draining or flooding salt marshes and for draining large bodies of fresh water, such

as the ponds at Roslyn, can be carried through without legislation conferring upon the public authorities the necessary powers to that end, and providing means for raising the necessary funds by the sale of bonds. It is believed that the time is near at hand when such legislation will be enacted.

For the Executive Committee,

WILMOT T. COX,
Secretary.

General Engineering Report, Henry Clay Weeks, Engineer in Charge.

PRELIMINARY REMARKS.

The inception of the general movement to exterminate mosquitoes on a section of the north shore of Long Island may easily be traced to the fruitful experiments made by Mr. Wm. J. Matheson at his historic home at West Fort, Lloyd's Neck, in the Summer of 1900, and to the results of some drainage operations at his former place at Nissequoge, farther east on the island, which were undertaken a year or so previously. Mr. Matheson had become convinced of the practicability of the idea that mosquitoes could be exterminated from the Oyster Bay section, and had invited Dr. L. O. Howard, Chief Entomologist of the Department of Agriculture, Washington, to visit the section, with a view of obtaining from him an opinion as to this idea. Dr. Howard's visit, in the Summer of 1900, resulted in his forming an opinion that such relief might be had for the entire section through concerted action over a large territory, and it was through his suggestion that the writer might be profitably called in to aid such a scheme that the writer's connection with this movement is explained. (Dr. Howard had also, on invitation, visited the section around Flushing, L. I., in the spring of the same year, and had expressed his conviction that that section also could be relieved by forceful action, but nothing resulted for want of a backing to the project.)

Mr. Matheson's hope to interest the owners in a large territory, during 1900, did not carry, but the result of his enthusiastic interest in the subject led to the matter being taken up by a small section, namely Center Island. After part of a successful season's work there during 1901, on lines planned during a hurried reconnoissance by the writer in 1900, and as formulated at that time in a written report to Mr. Matheson and others, the interest of the large territory was in the end awakened, and the present movement is the

result. A brief account of the Center Island work from its inception is made the subject of a separate report herewith. From a reading of this latter there may be gathered very general ideas of what is to be done for relief. But as every situation has its peculiar characteristics, no plan for one place is entirely applicable to another.

THE SCOPE OF THE REPORTS OF ENGINEER.

There is here submitted general considerations on each class of breeding grounds, such as isolated ponds, ice-ponds, salt marshes, mill-ponds, and other water areas, as well as domestic sources. These will be followed by such subjects as the cooperation of the authorities, and general topics.

The important features of districts will be taken up in geographical order, commencing on the west, and the recommendations for them given in the Detailed Engineering Report.

The particulars of size, owners' names, and treatment of isolated ponds, etc., will be found in the Indexed Report of Engineer. The approximate cost of the relief works proposed is given at each place described in these last two reports.

The amount of detail in the work necessitated by your "outline of plan" has taken more time than was anticipated, and involved walking and driving tours aggregating about one thousand miles.

ISOLATED PONDS.

Aside from the artificial sources of trouble, such as cisterns, rain-barrels, etc., there are only two other extensive sources to be considered—namely, the brackish pools on salt marshes, and the fresh water courses and ponds entering into the salt marsh areas. Interior natural fresh water swamps do not exist to any considerable extent. Those made by man in damming streams for mill-ponds are not lapses of nature.

A serious though small source of difficulty exists in the many isolated ponds which were found to occur in the table-lands well back from the shore. These number several scores, and for various reasons are generally difficult to treat. They are often found in what is known as kettle-holes, the theory of whose formation is, that masses of ice from the glacial period have rested at these points, and the soil has

settled beneath and around them, thus leaving depressions of more or less extent. Probably the most notable one in all the territory lies a little north of the residence of President Roosevelt, and is about sixty feet deep and of small diameter. In this particular case, however, the subsoil is of a sandy or gravelly nature, and thus the water from the surrounding watershed quickly soaks away. But in many of the others of these kettle-holes the subsoil is of a clayey nature, and this prevents percolation of the rain-water. When this condition exists and there is a large watershed, there will be difficulty in getting rid of this source of trouble. One method suggested is that an excavation, of diameter proportionate to that of the ponds, be made in the deeper parts of the shallower ponds, through the stratum of clay, and if possible down to gravel. Then fill this excavation with field-stones and place upon them a thin surface of porous earth. There may be mentioned an instance on the writer's own property where such a course was pursued, and the pond, which was large and prominent enough to be charted in an early map, has been entirely obliterated.

Where such treatment is not practicable, it is recommended, in some cases, that these ponds be filled with field-stones to the ordinary depth of the water, and their surface then covered with a soil which can be cultivated. Of course a better treatment, in as many cases as possible, is to drain off these ponds by an open ditch or by a pipe sunk in a covered trench to the depth of the lowest point of depression. In cases where the depresssion is slight it can be filled with soil only.

But one great difficulty which will be met in the treatment of these places is the strong desire which their owners have to preserve them. From numerous interviews, it is clear that many owners are blinded to the foul condition of the waters and of the soil around and beneath them. Often houses and barns seem to have been located in early times near to these ponds with a view of maintaining them as duck ponds, or as watering places for the stock. By reason of such location these depressions have become receptacles of all the domestic refuse of the watersheds.

As a rule, those few places which are partially fed by springs can be the most easily drained, for nature generally provides an outlet for all spring water, or by slightly assist-

ing nature, where the outlet is clogged, the water can be readily got rid of.

In the case of many ice-ponds it would be possible to drain off a pond by a gate in the Spring of the year and allow the bottom to be cleansed by spring rains, the pond hole to remain dry during mosquito season. The gate could then be closed in the late Fall, and the water would accumulate from the Fall rains, from which a supply of much purer ice could be obtained. This course could be pursued also in larger areas where ice is gathered.

Where drainage or filling is not possible, the use of oil is the surest resource, and as so little need be used and that little evaporates so shortly, this treatment could be employed in the breeding season and afterwards the pond used for ice without objection.

FISH IN PONDS.

The installing of fish to destroy larvae, to the writer's mind, is seldom entirely effective, and the findings of the entomologists in some places where fish were claimed to exist confirm the doubt. One difficulty is that larvae escape fish in the water left in the tracks of animals and in other little side pools where they cannot penetrate. If a pond had a supply of good water, and its edges were kept sharply defined, say by a stone wall laid in cement, the difficulty would be reduced. But this is rarely the case. Dr. Howard gives the best varieties of fish for the purpose in Bulletin 25, New Series, Dept. of Agriculture, but in his later writings he strongly favors the common gold fish, not only as very voracious, but easy to obtain.

UNUSED MILL-PONDS.

Very early in the consideration of the remedy for such danger points as old ponds, frequently right in the center of a village, a conclusion was reached which time has not altered. The findings of the entomologists later, and the statements of physicians, show these places the greatest, because the most extensive, menace to health in populated places. In every instance where these relics of early time exist, there was found malaria strongly prevailing. As one physician remarked, we have always known that such places induce malaria, but it is only recently that we have known

that this is simply because they are the breeding places of *Anopheles*.

Later, when on a tour with Professor Shaler, the intention being to let him see the condition of these old ponds and draw his own inferences, he said forcibly and briefly, "I shall recommend that such places be wiped out," thus, without conference as to methods, agreeing with the judgment of the engineer, formed a long time before, and for an estimate on which plan data had been previously obtained.

Looking at the question from the view of the utility of mill-ponds, this suggestion may seem far too radical, but when it is considered that at one period there were in the territory examined about twenty-two of these fresh water mills and that of them only three are still running—one each at Cold Spring Harbor, Oyster Bay and Roslyn—the utility argument nearly falls to the ground of itself.

While of course the three mills at present running have legal or other rights, it would become proper to regard those rights as a part of the expense of a plan of improvement—provided valid objection was made to the ponds supplying them. Of these three, however, it will be observed in the Detailed Report, the recommendation to obliterate is only made in the case of one, and in that case that seems to be the only safe plan. The other nineteen of these mills are in ruins—a fact which shows that these places are, for this section at least, relics of a bygone age and of methods now superseded. In a few cases even the connecting ponds have already been run out and improved conditions prevail.

There are doubtless mill-ponds in different sections of the country where there can be no objection to them as being breeding places—where they are supplied from strong hill or mountain streams, where the margins are sharp and so are without pools or animal tracks, where the mill-race is not troublesome by reason of clean banks along which pours a strong stream to supply a large plant—a pond where, besides, there is so much depth of water that larvæ cannot easily descend and feed on the bottom as some species do, and where voracious fish abound, as they would under such favorable conditions.

But these conditions do not exist in this territory—especially not in the only instance where it is recommended to do away with the pond—though a mill is still running in

a small way. And if in this instance, or any other, where a pond is to be maintained to satisfy the demands of a community, there ought to be, and in all of our cases would have to be a large outlay to make them comparatively free from breeding any and all kinds of mosquitoes—for that is the primary object of this whole movement.

It might be pertinent, as well as of interest historically, to enumerate these old mills, where there has had to be a dam erected in all cases, probably long before the memory of any one living, some no doubt going back about two centuries. Commencing at the east, there were three at Cold Spring Lakes—one only now running ; one at Bungtown, opposite Cold Spring Village, on the northwest corner of the Oyster Bay road and that leading to Laurelton—pond and mill gone ; one at Fleet's Pond, south of Cove Neck, on road to Oyster Bay—pond exists but mill is gone ; one west of Oyster Bay village on the shore road—mill now running ; one at upper Francis Pond, Mill Neck ; one where now is an island in the same ; one at lower Francis Pond—mill standing but unused ; one at Kaintuck Pond, just north of the railroad, after it crosses the causeway over Mill Neck Marsh ; one formerly run by the same water, but to the south of the railroad and about three hundred feet southwest of the last mentioned—here the pond has broken through the dam, and the bed of the old pond is quite dry; one at what is now known as Remsen's Pond, on west side of Mill Neck Marsh, half way on road to Bayville ; two at the Glen Cove ponds —the last one now being demolished ; three in the Glen Wood section—one now occasionally running a small saw; a glass mill just south of the Bryant place, Roslyn ; two (probably three) on the Roslyn ponds—one now running, and a ruin of one—a paper mill said to have been visited by Washington ; one northwest of the village on west shore road.

Possibly there were still others not here mentioned. There were certainly a few others where but a little power was used.

The waters are now far from being pure as they once were. Every house that is built on the watershed increases the danger. The increased traffic on the bordering roads, with the resultant increase of horse refuse, is another factor of pollution. Generally, houses, stables and privies are

drained into them. Thus the bottoms are simply an accumulation for many feet of the pest-bearing wastes of the community. Nor do the rains help to purify—rather the reverse, for they bear the more wastes into the pond bottoms, and when their burden has been deposited they flow generally from the top surface over the dam and so to sea. There would be a slight improvement of sanitary conditions if the water was always drawn from the bottom and thus carry away the foul accretions there. The engineer was fortunate enough to see two of these ponds partly drained, and the bottom, as far as could be seen along the shore, was simply a mass of vile ooze. One of the physicians said that some years ago a dam broke away and left the bottom of one of the ponds bare, and, as it was in warm weather, the stench was intolerable, and there was a great protest until the dam was repaired and the area was re-flooded. In his opinion, the condition of these ponds is getting worse yearly, and a concensus confirmed this opinion.

They will all unquestionably become more and more extensively the habitat of *Anopheles*, as this species spreads, until, throughout the surrounding sections, malaria will be endemic.

When such a condition confronts these sections, it would seem that the question of aesthetics, or indeed any question, should have no weight. But would the sections really become less picturesque than they are now in most of the places where the rears of the buildings, stables, sheds and outhouses are the conspicuous features—where debris of every nature finds a convenient receptacle? Let us see what might be done with one of these specimen pestiferous ponds—whether it could not be made quite as picturesque as it now is—valuable land utilized, and the dangerous conditions obviated.

We will suppose a pond in the midst of a growing section, or a section that would grow if conditions were favorable, where capital has become interested, and the newcomers have the desire to aid in improvement. The pond itself has all the usual dangerous features increased through the course of a long mill-race filled with brush and other accumulations. The village cannot spread, as hills run down to its borders, and thus any land that could be utilized in the valley is valuable. There is plenty of land, but it is covered

by two or three feet of foul water, which, if run off, would leave an opportunity for buildings or for a parking scheme.

The still reaches, which always occur at the end of a pond opposite the dam, and which have become partly covered with an impenetrable growth of bushes—places very liable to breed *Anopheles*—would be redeemed; in fact, all of the area from the rear of the line of the houses on one side to the rear of the houses on the other side of the pond could be made a place of beauty. All the space that would be needed to reserve would be for an open main drain through the centre of the pond area; other drains to lead the water from springs or rainfalls into it could be covered. Buildings could be made to connect into these drains at a slight expense, and, as the exigencies required at a later time, all drains could become the lines of a system of covered sewers. Thus every rain-storm would be the means of purifying the area, while now it is only a means of accumulating the filth of the village.

In furtherance of a parking scheme, the bushes, stumps and debris could be cleared out, a system of drives and walks could be arranged, trees and ornamental shrubbery could be set out, grass could be grown upon the once muddy bottom, and thus the moisture and decaying matter would be absorbed. If it was desired, all of the houses backing on this typical pond might be removed to another site, and the road encircling it and skirting the foot of the surrounding hills could be made a beautiful drive by having a park entirely on one side. Such a park could become the site for a library or public hall—the rendezvous of the local Village Improvement Society. It could also be, as in so many New England villages, the site of churches built under permit as to location, expense and plans, and thus it would become a still more beautiful feature.

If it should be thought that such a plan is too radical or would involve too great expense, let it be considered that no outlay on a typical stagnant village as pictured would be more warranted and repay in greater returns. The village would become known as a healthy, picturesque place, and people would be drawn to it for residence. On the other hand, to let such a village remain as it is, its growth would be retarded, and it would stand for years to come without considerable extension or improvement.

The village under the new conditions could be conscientiously recommended by the physicians as a safe place of resort for summer or permanently. If an unqualifiedly favorable answer could be given when persons are seeking, as the physicians report they often do, information as to healthfulness, how great would be the material growth of the new village, and how large would be the rate of return for the outlay in making it safe.

Mostly all the work connected with such a scheme could and should be done at a season when the sun is not strong enough to increase the decomposition of animal and vegetable matter found in the bed of the pond. The work could go forward in cool weather and be advanced so as to have no objectionable features the following summer. A transformation such as could be effected along these lines would make any village famous, and yet it is all possible and very practicable through the co-operation of the authorities and individuals working separately or in improvement societies.

DOMESTIC BREEDING PLACES.

No specific directions are given by the engineer for the treatment of such domestic breeding places as cisterns, water-barrels, tanks, or the like. The entomologists' report shows that there are many hundred such places within the territory. It may be safely said that there is scarcely one house but that has some such places. The work of the Association, to secure the abolition of these places, must be at first entirely of an educational character—after that the authorities must act if the places are continued. When the larvae have been shown the residents, they have almost universally acknowledged that they were not aware that mosquitoes bred from these "wigglers." Occupants of houses must first be informed of the danger from mosquitoes, and then instructed in their ways of breeding, and how to destroy them with oil if breeding has started. In this way their cooperation should be secured rather than by an attempt to treat them through regular visits of an agent of the Association.

The fact, however, must be thoroughly impressed upon all persons who attempt to abolish or protect their domestic breeding places that their work *must be thoroughly done*. If, for instance, rain-water cisterns are to be kept, every avenue of approach to them must be completely protected—the top

covering cemented down, the open top pump above it covered with close netting, and all of the leader pipes tightly screened at their tops. An instance is known to the writer where clouds of mosquitoes had been seen issuing from the opening in the gutters at the top of the leader pipe, and the occupants of the house never thought of the supply being furnished from the cistern water many feet beneath. Mosquitoes will seek water for breeding as naturally as tree roots will seek moisture for sustenance—well-nigh irresistibly.

FEW SAFE FRESH WATER AREAS.

It will be noticed that there are some ponds not charted as to mosquitoes. These, mostly, are ponds beyond the area which the entomologists examined, the engineer going to the apex of the watersheds on the south. At the time of his visit to such places the season was too late for finding larvae.

But it is not too sweeping to say that in all the territory examined there was scarcely one water surface which might be called safe, judging from a knowledge of the habits of the pests. The safe sections, if any, would be those fresh water places having a strong supply of good water, whose banks were made secure against any quiet water occurring. Though the examination of a pond might not reveal larvae on a particular day, yet oviposition may occur very shortly afterward and trouble result. Mosquitoes will breed in almost any fresh water, and it is safest to act according to that theory. There are some times and situations, also, in which it is difficult to detect larvae though they really exist. In the examination of 1900—too late for larvae—certain points were reported as breeding places of certain kinds. For example, of a foul place in a certain village it was said it would breed *Anopheles*. This was confirmed by the entomologists in the larvae season of 1901. The early report fixed a breeding place, favorable to supplying all Cold Spring, at the old railroad embankment west of the middle lake, and the entomologists say of it that it should be rated *Anopheles* four, though three is the highest grade it was determined to chart. Necessary results followed in both these instances.

As to the speed of water to prevent breeding, the Italian investigators have the theory that the rate of one mile per hour is prohibitive. But in accepting that idea, it

must be remembered that the water at the edge of a stream is less rapid than its middle.

SALT WATER BREEDING.

On the question of mosquitoes breeding in salt water, it has been the theory in this country that they do not, but a writer in the London *Lancet*, several months ago, stated that in his opinion they did so breed. Dr. Howard expected to make some experiments along this line, but was not able to do so this summer, and referred the writer to Dr. John B. Smith, of the Agricultural Station, New Brunswick, N. J. He says: Experiments just closed positively show that *Culex salinarius* will breed in water that is as salt as the sea, even in water whose content of salt is twenty-five per cent. greater. His experience also shows that this species breed *only* in salt water, but he agrees with the writer's opinion that where tides move strongly over a marsh no breeding will occur, unless in the unfilled marsh holes. Salt marsh pools are by far the most prolific breeding grounds, and the treatment necessary to prevent breeding there is by so far the most important consideration. While it is not considered that these marshes breed *Anopheles* to a dangerous extent—Dr. J. B. Smith claims that he knows of their breeding in brackish water—yet the breeding of *Culex* in such vast numbers in these places demands very careful study of conditions and methods of relief.

TREATMENT OF SALT MARSH AREAS.

There are a number of ways in which salt marshes may be treated. The first and safer way is to shut the tidal waters completely off the marshes by a gate closing automatically on the rising of the tide but which will allow the escape of the inner water at low tides, and by ditching the marshes thoroughly, thus drying them off, by drawing all the interior waters down to the tide-gate. Then it is necessary that all marsh pools should be filled or drained out to the ditches, so that they may hold no rain-water. This plan accomplishes most in a commercial way for the marshes that is possible, for the reason that the creeks may be filled up and the surface subdued and valuable land brought into cultivable condition. It is considered that the overlaying of marsh by intertide soil, thus burying valuable land, should be done only as the very last resort.

Another way would be to erect a gate at the outlet of the tidal stream, arranged so that the water would flow in and be maintained up to a certain level—say two feet below the level of the marsh. In this way, unsightly tidal flats or creek bottoms would not be exposed to view, and the depth of water would generally be enough to allow the use of boats within the gate. The pools would then have to be filled with soil from the uplands.

Still another way was proposed by one of your committee early in these investigations—namely, to destroy the breeding places by completely flooding the area by an automatic gate which would hold the water in. It is not considered that there are any situations in this territory in which this scheme would be practicable, for the reason that there are no fresh streams entering the marshes of sufficient strength to maintain the level of the water above the marsh, which in almost every case in this section is about that of high tides. There are not many very young marshes where tidal flats exist, nor yet places where the building-up process has brought the marsh levels above that of ordinary high tides. So that in order to effectively guard against danger of breeding at the edges of the marsh the water should be kept at a level of about one foot over the marsh level. To preserve the water at that height, without a strong stream entering it from the uplands, to offset the loss by percolation at all tides, and especially at low tides, as well as against loss by evaporation, both large factors, it would be necessary to have an extensive pumping plant installed, which, in usual cases, would be most positively prohibitive. The plan of flooding would answer a purpose, in case of tidal flats, but could not be applied with the ordinary marsh conditions.

In the foregoing methods it is supposed that there are no rights to the stream as navigable water.

It sometimes occurs where the marsh enters but a little distance into the land area, and there is but little or no elevation along the outside shore line, that the expense and trouble of reclamation are disproportionate to the commercial results obtained, especially if there is a long distance from which the materials for the dike have to be brought. In such a case it may cost many thousand dollars to reclaim but a few acres.

On the other hand, where the marsh enters deeply inland, it sometimes occurs, through the building up of high barriers by the sea and by the growth of sand-retaining grasses on them, that by a little labor the barrier may be completed and the sea shut out at a comparatively trifling expense. In this way scores of acres may be redeemed at slight cost.

Instances of both situations exist in the territory examined.

OTHER WATER AREAS.

In the examinations which were required in the case of streams so as to estimate the amount of excavation required for their free flow, there was necessitated a tour of many miles, an inspection of bridges, a consideration of the extent of the watershed, and what filling and grading would have to be done in order to preserve the regular descent, and thus get rid of all standing water. The streams through the valleys running up from the shore generally follow the old lines of thoroughfare, such as through Woolver's Hollow to Mill Neck and through Poverty Hollow to Oyster Bay. Such thoroughfares are usually the growth from old Indian trails, and later of bridle paths up through the valleys to the interior. The pioneers found their easiest way from low land to high land to be up through the sides of the water courses. So that, in such cases, the work for the grading for these streams, being at the roadsides, should be the work of the town. Occasionally the course of the stream, especially when it becomes torrential, is through private lands, and frequently there is left after the Spring rains pools which do not dry up soon enough to prevent one or two crops of mosquitoes. An instance in which the lack of grading of a roadside prevents a free descent is clearly seen in Brookville, where the water from some springs about 200 feet from the road finds its way into the roadside and runs quite a distance along it, finally forming pools near dwelling places where entomologists report *Anopheles* and *Culex* larvae very abundant.

COOPERATION OF THE AUTHORITIES.

The increase in the interest on the subject of extermination was well shown by the cooperation of the authorities in

the examination of premises. Town authorities and health officers aided by appointing the specialists as inspectors, and in all the examinations in the different lines there was but little opposition, though one of the entomologists was afterward described to the engineering party as a crazy man looking into rain-barrels, expecting to find mosquitoes there.

But from the present general status of the question, it is thought that there will be but little trouble in enlisting the action of all the authorities, so that the plan of the Association in this regard may be carried out.

The authorities should be visited and arrangements made for a hearing of your committee on what ways cooperation would be most effective. Ordinances will be needed if the good results accomplished in the City of Winchester, Va., and elsewhere are to be obtained. (See Appendix II.) Health Board condemnation of premises and ponds must be followed by the abolition of foul places; Highway Commissioners must aid by grading to relieve the roadside ditches of water; cooperation between County Medical Societies and Health Boards would be very helpful and should be enlisted.

LEGISLATION.

Even State legislation must be asked to supplement defective laws, and possibly in some situations National approval must be obtained. In many cases there will be no other way to obviate danger points than by official action, either under existing laws or under laws which may yet have to be enacted.

(Signed) HENRY CLAY WEEKS.

Bayside, Long Island,
New York City, December, 1901.

Entomological Report of Professor Charles B. Davenport.

PRELIMINARY.

In August, 1901, the North Shore Improvement Association of Long Island undertook to have a careful biological and engineering survey made of the territory in which they are interested with reference to the possibility of eliminating the mosquitoes occurring there. The territory over which the preliminary survey extended reached from the east shore of Cold Spring Harbor to Hempstead Harbor, and from Lloyd's Point to Roslyn, and from Dosoris Island to Cold Spring Station, including an area of about 75 square miles. The biological survey, which aimed to locate the position of the breeding places of larvae, was made by Prof. C. B. Davenport and Messrs. F. E. Lutz, W. W. Chambers and C. B. Bennett between August 15 and September 15, 1901. The detailed reports of Messrs. Davenport and Lutz are given below.

The purpose of the investigation was, as stated, to locate the breeding places of mosquitoes with a view to abolishing them. It is believed that by appropriate means the mosquito can be abolished, and with the abolition of the mosquito will go malaria; for it is now generally recognized that malaria is disseminated solely by mosquitoes.

THE LIFE HISTORY OF MOSQUITOES.

A mosquito develops from an egg that is laid in water. After a few days the mosquito hatches and passes its babyhood in the water as a "wiggler" (Fig. 1.). At this time it grows rapidly and changes the proportions of its elongated body. After it has acquired a certain size and age it suddenly gains a much enlarged head and chest and is known as a chrysalis or pupa. After a brief period the outer case of the pupa splits along the back and the adult winged mosquito crawls out. It rests for a time in the old pupal case, which floats meanwhile like a boat on the surface of the water. At this time the mosquito dries its wings and then

makes its departure into the air. There are male and female mosquitoes. The former have feathered feelers or antennae and do not bite.

THE TWO PRINCIPAL KINDS OF MOSQUITOES.

Naturalists recognize nearly a dozen gnat-like insects that bite. For our purpose these may be grouped under the two names *Culex* and *Anopheles*. *Culex* is the commoner. *Anopheles* alone disseminates malaria. They may be distinguished as follows:

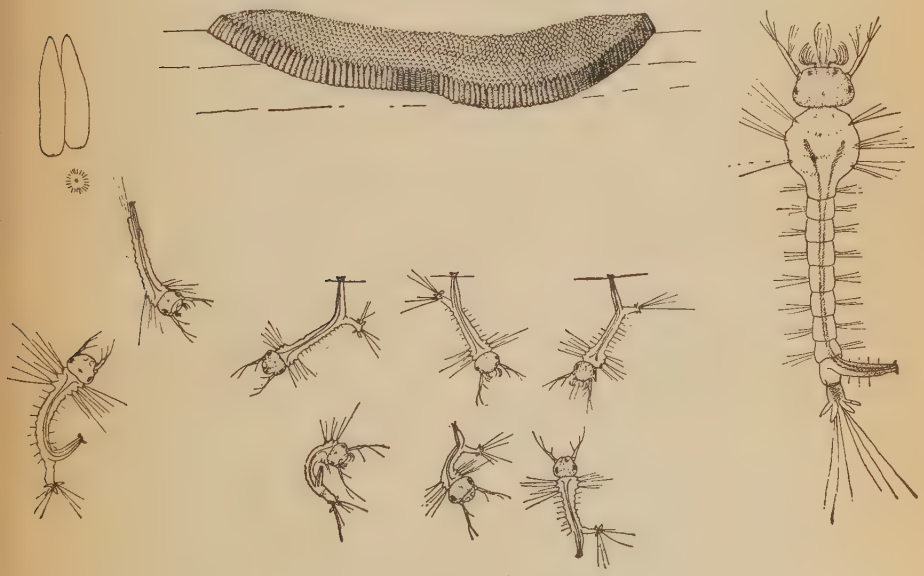
The larvae of *Culex* has a long breathing tube (Figs. 1 and 2) by which it gains air though living in the water.

It hangs obliquely, head downward from the surface film of the water.

When disturbed it drops quickly with many contortions to the bottom.

The larvae of *Anopheles* has a short breathing tube (Fig. 3).

FIG. 1—CULEX EGG MASS, ENLARGED EGGS—ABOVE.



CULEX WIGGLERS.—BELOW

L. O. Howard, Div. of Entomology, Bul. 25—New Series.

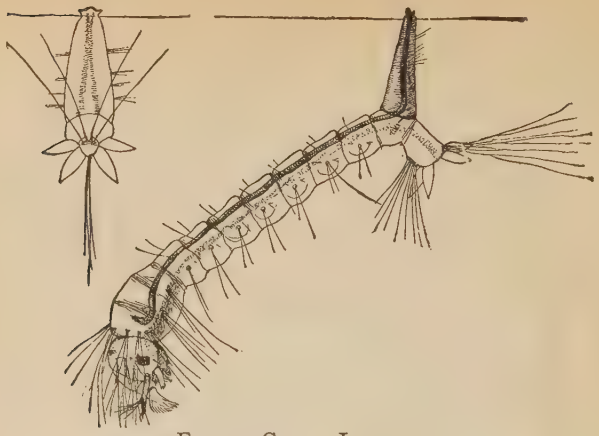


FIG. 2—CULEX LARVA.
L. O. Howard, Div. of Entomology, Bul. 25—New Series.

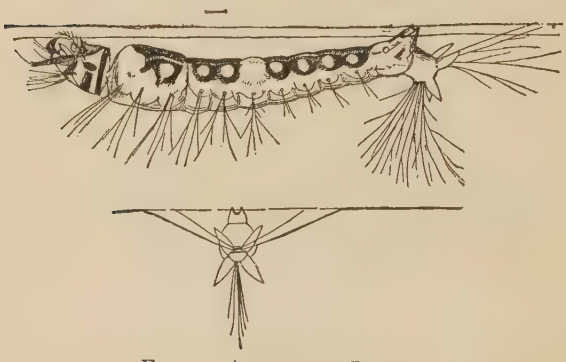
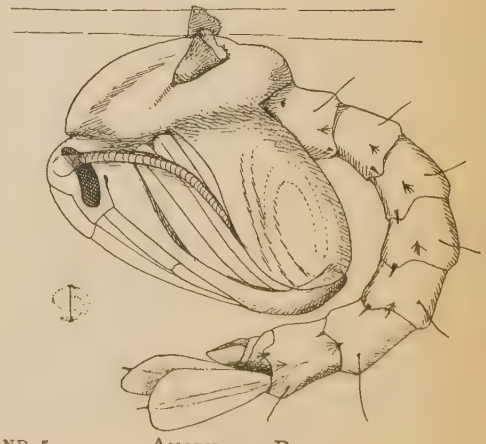


FIG. 3—ANOPHELES LARVA.
L. O. Howard, Div. of Entomology, Bul. 25—New Series.



CULEX PUPA. FIGS 4. AND 5. ANOPHELES PUPA.
L. O. Howard, Div. of Entomology, Bul. 25—New Series.

CULEX ADULT. FIGS. 6 AND 7. ANOPHELES ADULT.
RESTING POSITION.

L. O. Howard, Div. of Entomology, Bul. 25—New Series.

It lies in a horizontal position just below the surface film.

When disturbed it slides along under the surface film or drops quietly a short distance.

The pupal stages of *Anopheles* and *Culex* are shown in Figure 4. They are hard to distinguish without a careful examination.

In the adult condition the two forms are distinguished as follows :

Culex has a one-pronged proboscis in the female, *i. e.*, the palps are short; when resting on the ceiling its body is nearly horizontal and its hind legs hang over its back; in any situation the head and beak make an angle with the trunk.

Anopheles has a three-pronged proboscis, *i. e.*, the two palps are long; when resting on the ceiling its body hangs obliquely downward and the hind legs dangle on the ventral side of the trunk; in any situation, the beak, head and trunk form one straight line.

THE ELIMINATION OF THE MOSQUITO.

The possibility of mosquito control depends first on the fact that mosquitoes have an aquatic stage, and secondly on the circumstance that the adult does not fly far from its breeding place—*Anopheles* probably not more than 200 yards; *Culex* a half-mile, or, exceptionally, several miles.

There are three principal ways of eliminating the breeding places of mosquitoes: First, by draining (including filling and other engineering operations); second, by petrolizing, or pouring petroleum on the water so that it forms a film which smothers the larvae; third, by cleaning the ponds of vegetation and stocking with fish, especially sunfish and top-minnows (or other larvicidal aquatic organisms). Which of these methods shall be employed in any case depends upon the nature of the breeding place. Springy, boggy ground, many salt marshes and surface ponds and small slow-running streams require draining; holes in the ground and in trees should be filled; rain-water barrels should be petrolized once a week and the water drawn by a spigot from the bottom; small ponds may be treated by petrolizing ; stocking with fish is applicable to cisterns, fountains, clean ponds with sharp edges all around, and to clean but sluggish streams that cannot well be drained. In villages and about barnyards standing tubs or buckets of water and discarded kitchen ware holding water are often prolific breeding places, and should be emptied once a week, the period that it takes *Culex* to mature.

The relation between mosquitoes and malaria (fever and ague, chills and fever, intermittent fever) has already been referred to. It has been shown that even the worst malarial regions are harmless to persons who keep themselves from being bitten by *Anopheles*. It is not so hard to keep from being bitten, for *Anopheles*, unlike *Culex*, flies and bites only after sunset. By retiring early to an adequately screened house and remaining there till morning one may live in a malarial region without contracting the disease. The malarial parasite is an organism which, like many other parasites (*e.g.*, the tapeworm), requires two hosts to complete the cycle of its development. In the case of the tapeworm, these two hosts are man and the hog. In the case of the malarial parasite they are man or some other warm-blooded animal and the mosquito.

The foregoing facts show that, in order that malaria may be disseminated in any community, infested people and *Anopheles* must both be present. If there are no malarial patients in a community and none are permitted to enter, the *Anopheles* are harmless so far as dissemination of disease goes. On the other hand, one may live in a sanitarium of malarial patients without danger of infection if *Anopheles* be absent. To rid a place of malaria, either the malarial patients must be exported and a rigid quarantine established against those who have recently had the disease, or else the *Anopheles must be exterminated.* The latter procedure is usually the most feasible. The efforts of the North Shore Improvement Association have therefore wisely been directed toward that end. The theory that *Anopheles* disseminate malaria is well sustained by the investigations made. Time and time again it has been found in the field that there was abundant malaria where *Anopheles* was abundant in a fairly thickly settled community.

Figures.

1. *Culex* wigglers (from Fig. 1, Howard's Notes on the Mosquitoes of the U. S. Bull. 25, p. 23, U. S. Dept. of Agriculture).
2. *Culex* larva.
3. *Anopheles* larva.
4. *Culex* pupa.
5. *Anopheles* pupa.
6. *Culex* adult.
7. *Anopheles* adult.

CHARACTER OF INVESTIGATION.

The investigation was made largely on foot, penetrating across fields, along river courses, and often through dense thickets and brambles. In the case of villages, a house-to-house inspection was made to pick out artificial breeding places. To aid inspection, when the larvae, which were the main object of our search, could not be directly observed, a net of cheese cloth, somewhat larger than a man's hand, and a large kitchen spoon were used—the former for straining out larger quantities of water, especially in grass around the edges of ponds, the latter for examining small bodies of water such as the footprints of horses and cows.

The results of the examinations are given in note-books intended to be given directly to the engineer corps for their use. The main results are given further on.

CERTAIN GENERAL OBSERVATIONS.

Such a study as we have made could not fail to establish certain generalizations in respect to the breeding places of mosquitoes, and these it may be worth while to put on record.

1. HOLES IN TREES.

The importance of holes in trees has already been recognized. Our observations are strongly confirmatory.

2. FOOTPRINTS OF ANIMALS.

The importance of the footprints of live stock in boggy ground has not, so far as we know, been mentioned. We find that vast numbers of larvae breed in this situation. It often occurs that larvae, even of *Anopheles*, find no breeding place by a swift-running stream, except in the footprints along the banks. Also in boggy ground the only exposed water is that which has drained into footprints.

3. VEGETATION.

The influence of vegetation is very great upon the breeding places of mosquitoes. Contrary to a widespread opinion, we do not find that cutting bushes in swampy ground is always beneficial. On the contrary, if the water does not rapidly evaporate it becomes warmed, and *algæ* grow in it, permitting of an unusual development of larvae. We have repeatedly noticed that swamps in which cat-tails were standing contained few or no larvae, whereas those from which the cat-tails had been cut off contained abundant larvae. Similarly, streams fed from springs have few larvae while in the thick woods, whereas the larvae become at once abundant on the borders of the streams as they emerge to the sunlight. It is uncertain whether this sudden increase is due to the higher temperature of the water in the sunlight or to an increase of the *algæ* used as food by the larvae. Again, we find that mosquito larvae do not develop well in water covered by a layer of iron rust—such as indicates the proximity of an iron spring. Such places need hardly be inspected in looking for larvae. Larvae, then, do not thrive in cold spring water in the woods or shaded by vegetation, nor in iron waters.

4. SPRING WATER.

We find that larvae, especially of *Anopheles*, reach their maximum development of numbers in those regions where

there is an abundance of pure cold spring water, but almost only when that water stands exposed to sunlight. The reason for this is probably that spring waters (so-called ground waters) permit of greater growth of microscopic algae than do surface waters. The algae grow only in the sunlight. *Anopheles* feeds on surface microscopic algae.

All of this points to the important practical conclusion that those places where springs outcrop are to be especially attended to, that the clay stratum is to be drained above the level at which it outcrops, and the water led to the sea, due provision being made for the supply of houses which depend on this source for water.

A summary of the conditions as to breeding places of mosquitoes in the territory examined by my assistant, Mr. Bennett, and myself, by Mr. Lutz and his assistant, is appended.

November 1, 1901.

(Signed) CHARLES B. DAVENPORT.

Report of Mr. Frank E. Lutz, Biologist.

In the history of economic entomology there has probably never before been such general interest taken in any class of insects as has been manifested in the last year or two with respect to mosquitoes. This is due largely to the discovery of the curious and startling chapters of the life history of the malarial parasites and spreading of this knowledge by the United States Division of Entomology and the public press. Not many years ago the mosquito was universally regarded as a troublesome but necessary nuisance, and even during the last season we were constantly met with ridicule and opposition from those who, either on account of ignorance as to the seriousness of the work, or by reason of dogged persistence in the idea that "whatever has been, necessarily must be," were wholly out of sympathy with any efforts to abate the evil in their community. But I am glad to say that, in the district as a whole, such individuals are greatly in the minority. By far the larger number were intensely interested in what was going on, willing to do their share of the fighting, and anxious to learn all they could in the little time we had to spare of the different kinds of mosquitoes, their life history, their connections with disease, means of getting rid of them, etc. In what follows I have tried to bear in mind these questions, and collect in one article such answers as I have been able to give, together with some other facts which may be of interest.

KINDS OF MOSQUITOES.

We have in the United States nine different genera of mosquitoes, but of these only two—*Culex* and *Anopheles*—need interest us in the present discussion, as the others do not occur on Long Island, or are so rarely seen as to be practically absent. The relation between *Culex* and *Anopheles* is the same as that, for instance, between our common rats and mice, and just as there are several kinds of each, *e.g.*, the house mouse, meadow mouse, deer mouse, etc., and

brown rat, black rat, etc., so there are several kinds of both *Culex* and *Anopheles*. It is but slightly more difficult to distinguish between the different species of mosquitoes than it is between the different mice, while it is quite easy to tell *Culex* from *Anopheles*. In a general way, the spotted-winged mosquitoes are *Anopheles*, although not all *Anopheles* have spotted wings. The surest way to distinguish is, that the female *Anopheles* (only females bite) appear to have a three-pronged beak, while in *Culex* there appears to be only one prong with a stub at each side.

LIFE HISTORY OF MOSQUITOES.

The life history of a mosquito is rather simple, but yet comparatively little known. It is divided into four epochs: First, egg; second, larva; third, pupa; fourth, adult. The egg, in the case of the *Culex*, is one of a boat-shaped mass of about two to four hundred other eggs. Almost any summer morning you will find several such black boats, each about a quarter of an inch long, in your favorite rain-barrel. Crush it and you can see the individual eggs, incidentally killing several hundred mosquitoes. From the under side of this egg issues the larval mosquito. It is the long, slim "wriggler" or "pole dodger." You can see five or six thousand in your rain-barrel any time during the season. The egg laid at night hatches into a larva by the next night. Now, if you take a tumblerful of this water containing several larvæ and carry it in the house, where you can watch it, you will see that it will, in about a week, moulting several times meanwhile, change into the hump-backed wriggler, of which you probably have already several thousand in your barrel. It is the pupa. Now, cover the top of your glass, for in two or three days this pupa's skin will split along the back and out will come a full-fledged biting mosquito.

What are the opportunities of a single mosquito in one season? As we have seen, their life history occupies ten days—we will say two weeks; this would give at least six broods a season. A female would lay from two to four hundred eggs—we will say two hundred; and consider that half of them die, for some reason or another, before they breed again. The first brood will give a hundred insects, of which half will probably be females; each of these

will have at least one hundred progeny, or 5,000 altogether. These 2,500 females will give a third brood, numbering 500,000, of which we will consider 250,000 meet an early death. The 125,000 females left give us 12,500,000 for the fourth, and so on until the last numbers, 31,250,000,000, or a grand total of 188,137,755,100. And we kindly furnish them the necessary water to breed in.

FOOD OF MOSQUITOES.

Now it is clear that of these billions we see only a small part. By far the larger proportion of female mosquitoes never taste warm blood, and no male ever does. Mosquitoes in their aquatic states are vegetable feeders and plant juices form the food of most of adults, if they eat at all. The adult insect lives chiefly for reproduction, and many kinds have even no mouth parts by which food can be taken in. This explains how there can often be so many mosquitoes where there are so few people or any other warm-blooded animal. But however that may be, I think we will all agree that enough do find us to make the summer quite uncomfortable, to say nothing of the menace to health.

HIBERNATION.

What becomes of the mosquitoes in the winter? Look under the boards that cover your cistern, or between the shingles of your outhouses. Here you will find them, sometimes in great abundance. They are the females, each full of fertilized eggs, hibernating, much as snakes, bears, etc, do. As soon as warm weather returns, out they will come to lay their eggs, and the merry round is started again. They do not, as some assured me this summer, appear spontaneously with the spring, generated from nothing. They have just as reasonable a life history as anything else.

BREEDING IN GRASS.

I am reminded here of another idea which was met at least once a week, sometimes even more frequently. It was noticed that in walking through grass, clouds of mosquitoes were frequently stirred up, and it was supposed that they bred there in the dew. Of course this is impossible from the facts which have been stated. It would be absurd to think of dew remaining on a grass-blade for over a week, even if a dewdrop were large enough to accommodate a larva—which

it is not, and furthermore over two hundred come from each egg-laying. The real explanation is much more simple. The mosquitoes are merely "roosting," so to speak, in the grass, possibly sucking the juices at the same time; and in walking by we scare them up and suffer the consequences. None of us suppose that crows breed in a corn-field simply because huge flocks are often found there.

MARSHES.

The most common mosquito of all on Long Island is *Culex sollicitans*. It is the brackish water form. *Anopheles* rarely breeds in salt water, but prefers cool fresh ponds and brookside pools. *Culex* may be looked for wherever there is standing water. It is never found in tidal flats or marshes daily flooded by the tides. But where only the highest tides reach, small pools are left which are diluted to brackishness by rain, and are often so full of mosquito larvae that, without exaggeration, there appear to be more larvae than water. The same is true where a slow stream flows into a harbor, as, e. g., Mill Creek. Low-lying pastures are most excellent breeding places from the *Culex* standpoint. Cattle tracks in such places make miniature aquaria, each one of which gives its share to the grand total. Good instances of this in different parts of this territory were found on the properties of Robert De Forest, Ira D. Remsen, Paul D. Cravath and T. F. Bailey.

But doubtless the source of the greatest trouble to those not directly on the coast is found in places entirely artificial —rain-barrels, tubs, buckets, cisterns, etc.

RAIN-BARRELS.

In the summer of '96 Professor Lugger, formerly of Minnesota, kept a sort of a census of the number of mosquitoes raised in rain-water in two barrels, and two counts will be given to show how many mosquitoes can be raised near the house or where they are most needed: "July 6, 1896, the water in one barrel was filtered. It contained thirty-five grams of mosquitoes, each gram by count numbering 217; hence 35x217 equals 7,595 larvae and pupae. Besides this, thirty-two egg masses, each containing on an average 302 eggs, were found; these would hatch into 302x32, which equals 9,664 mosquitoes. The total number of eggs, larvae

and pupae was 17,259. On July 22, 1896, by a similar process, 19,110 mosquitoes were counted in one barrel."

When we consider that often there is more than one barrel at each house (I found nine in one case), that a cistern is many times larger than a barrel, and that often there are tubs, buckets, tin cans, etc., galore, we must wonder where all the mosquitoes go to, not where they all come from. In Cold Spring village Mr. Chambers found over fifty barrels, in Oyster Bay over over hundred and fifty, in Locust Valley over forty, and in Bayville over thirty. A little arithmetic will show the necessity of constant carefulness on the part of every householder, and in absence of this a movement on the part of the community to force those without public spirit to do their duty in this regard, just as we now do in the matter of sewage and other public nuisances. For if an intelligent community, taking this up as a body, attends to its rain-barrels, etc., as it should, one careless—we refrain from a stronger adjective—householder could by retaining his pet hatchery bestow upon his fellow creatures the almost unthinkable gift of at least six times eighteen thousand, or one hundred and eight thousand full-fledged mosquitoes every season. Our friend who had nine barrels—as a matter of fact, two were the largest size hogsheads—furnished the village of Cold Spring with ten million or more mosquitoes during the long season of 1901. When I examined the premises of one strong believer in the South Side idea, I found two rain-barrels, two tubs, for dogs, I think, two unused cisterns, both alive, and numerous cans, buckets, etc., all wrong side up. I leave the calculating of the nightly output from this property to my readers.

TREES.

Turning to nature again, it was often asked where all the mosquitoes came from which are found in apparently dry woods, often miles from the nearest noticeable water. In every instance that was pointed out the woods were only apparently dry, and as a matter of fact, in the majority of cases, wherever a mosquito was noticed in the woods it was possible to find a breeding place within a radius of twenty feet. They were in the hollows of trees and stumps. Often the hollows are no larger than a wineglass, but the water is kept renewed by rain, either falling directly into it or trick-

ling down the trunk. The evaporation in the woods is very slight, and so the water rarely dries up. Secondary growth is especially apt to be affected in this way, for several trees growing around an old stump make a regular basin in the centre. The same is true of "twin" trees. Limbs broken off leave hollows which are enlarged by rotting, so that often there is a very small opening into a very large cavity that is never dry.

NORTH SHORE MOSQUITOES NOT FROM SOUTH SIDE.

After what has been said about artificial breeding places, and remembering that there are still some undrained meadows on the north side, it seems almost unnecessary to mention the South Side tradition. Even if it were so, the number brought by winds from the South Side of Long Island to the North Side would be so few, compared to the number you are breeding in your own yard, that it would be like carting coal to Newcastle. If asked, point blank, whether any mosquitoes came to the northern from the southern shore, I should say it may be possible, but it is not at all probable. If you will take the trouble to go in the neighborhood of a marsh when a high wind is blowing, you will find mosquitoes by the score clinging to the leeward side of trees, bushes, etc., as though their very life depends upon staying there. And it does. A fragile insect, like the mosquito, stands no more chance in a breeze than a frail skiff in the teeth of a northeaster. We can see how small a breeze will overcome them, for gentle fanning will give one almost complete exemption as long as the movement is kept up. When we think of the distance to be traveled, the hills and woods between, the nature of the insects themselves, and the fact that there is invariably a nearer and more plausible explanation, I think we must say that there is but small probability, even if we admit the possibility, for the sake of argument, of the south wind coming into the question. There is more chance of their being carried across by wagons, railroad trains, etc. We know how a cloud of these insects will sometimes follow our horses for almost a mile at a time, and it is barely possible that by a series of such followings batches of mosquitoes may be brought across the island. But they are as likely to be met by a team going south as one going north, and so, taking it all in all, we must

probably take the blame wholly upon ourselves, and confess that every community is breeding its own mosquitoes.

Have, then, the hundreds of observations which have been made, as to the fact that south winds bring mosquitoes, no foundation? I think they have. I know it is true for Cold Spring. This summer I made quite careful observations three times a day as to direction and strength of winds and abundance of mosquitoes. I give a typical two weeks. ("o" is a barely discernible wind. Grades run from that up to grade "3," which is a regular gale.)

Date.	*Wind.*			
July,	*7 a. m.*	*12 m.*	*7 p. m.*	*Remarks.*
7	Wo	So	S1	Mosquitoes common.
8	Wo	o	So	Showers.
9	E2	o	Wo	Few mosquitoes.
10	E2	E1	Wo	Few mosquitoes.
11	S1	S1	So	Showers.
12	N2	N3	S1	Showers.
13	SE2	S1	Eo	Few mosquitoes.
14	S1	So	Wo	Mosquitoes very bad.
15	No	S1	S1	Mosquitoes bad.
16	S1	S1	S1	Mosquitoes bad.
17	W1	Wo	Wo	Showers. Mosquitoes common.
18	SWo	W1	So	Mosquitoes bad.
19	Wo	W1	S1	Mosquitoes bad.
20	E2	N1	E1	Few mosquitoes.

It is here seen that there is a correlation between south winds and abundance of mosquitoes. This is made all the more striking from the fact that the observations were made with the determination to show, if possible, that such a correlation does not exist. What does it mean? These observations were made on the west side of the harbor just opposite Cold Spring village. To the south and within gunshot is the marsh at the head of the harbor. I feel prepared to say that the mosquitoes which the south winds bring to Cold Spring come from this marsh, and not from the South Side, as has been supposed. By counting the number of adult mosquitoes noticed at several stations along the lakes under various conditions, I found, (1) that mosquitoes are never as bad in the woods by the lakes as in the grass west of the meadow, to say nothing of the meadows themselves; practically no *Culex* are breeding in the lakes, but if the mosquitoes came from further south large numbers would stop in the woods at this point instead of being blown into

the open spaces beyond, there to lodge; and, (2) there seem to be more along the lakes during a long-continued gentle north wind, and less during a similar south one. It will be noticed that this is the opposite of that noted on the north side of the head of the harbor, and of course the opposite also of the conditions to be expected if the South Side tradition were true. The observation concerning the correlation between the mosquito plague and south winds is undoubtedly correct, but the inference in addition to its being contrary to what we know of mosquitoes is unnecessarily farfetched and improbable.

BREEDING PLACES OF ANOPHELES.

Anopheles, as I have said, are rarely found breeding in salt water. Furthermore, they seem to prefer water that is not stagnant or warm. On this last point there is need for further investigation, for it is not known what the factors are which influence the occurrence of Anopheles. I have never found them in ordinary rain-barrels, although there were several instances where barrels or tubs left in the woods contained large numbers. Only once did I find them in a tree-hollow. Once in a little-used watering-trough, shaded, and fed by spring water; and once in a barnyard pool in a springy district. Experiments and more detailed observations than I was able to make would richly repay the time spent, but, however that may be, I found them in *all* ponds, fed by streams, when the pond was not cleaned of vegetation and well stocked with fish. They were found in all meadow brooks under the same condition, for there is not a meadow brook in the territory so swift but that *Anopheles* can breed along the edges in the vegetation. For instance, it was stated by a physician that mosquitoes were not bred in the Locust Valley stream, as the stream was too swift, but Mr. Chambers found them not only present but unusually abundant. Italian investigators have fixed the maximum rate of flow in which *Anopheles* can breed at one mile an hour, but in the ordinary stream, where the edges are choked with vegetation, the rate of flow is often not that much in a day So all ground water is suspicious. It became evident in the summer's work that wherever Spirogyra ("frogspit"), duckweed, or watercress grows, *Anopheles* flourish. Have you ever seen any

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of these in the stream or ponds on your grounds? Only one pond was noticed where one or more of these did not occur. It was that of William Young, Oyster Bay, and here we could find no larvae, but the stream above it is not in as good condition. Streams in dense woods seem to be free, but fountains, springs, and all other ground water, stagnant or not, is apt to be dangerous and should receive careful attention. In fact, it seems that *Anopheles* will not breed in water that is too stagnant, although that is the favorite sort of ground water for *Culex*.

MALARIA.

This seems to be a fitting time to speak briefly and in a very untechnical manner of the disease which is now so undisputably linked with *Anopheles*. Permit me in this connection to quote from the address of Prof. R. S. Woodward, President of the N. Y. Academy of Science, to the Academy on February 25, 1901:

"I would invite your attention to one of the most instructive and beneficent of the many brilliant biological researches of recent times. No one who has suffered from repeated attacks of intermittent fever, and has survived the ravages of the *materia medica*, can fail to take a lively interest in the wonderful progress made during the last twenty years towards a definite knowledge of the natural history of that disease.

"It would appear that malarial fever has been one of the commonest disorders in certain localities with which man, in his struggle for existence, has to cope; and before the discovery of the properties of Peruvian bark it must have been a very serious affliction, by reason of its secondary, if not by reason of its primary effects. The symptoms, course and distinguishing characteristics of the disease, as well as the remedies therefor, were long known, however, before it was suspected that the mosquito had anything to do with its dissemination. Bad water, foul air and sudden extreme changes of temperature were supposed to be promoting causes. The dampness of marshes, swamps and other areas holding stagnant water was held to be an especially common attendant, if not inducing, condition. There was, indeed, no lack of acute and painstaking observations, and no lack of ingenious and well-supported hypotheses with regard to this widely

prevalent but obscure disorder. The detail of its diagnosis, prognosis, nature and causation, as laid down in the medical manuals of a few decades ago, are particularly interesting and instructive reading now, in view of recent developments.

"For example, Hartshorne, in his 'Essentials of the Principles and Practice of Medicine,' published in 1871, gives the following explanations:

"'No disease has ordinarily so regular a succession of definite stages as intermittent fever, namely, the cold, the hot and the sweating stage.' 'Upon the origin of malarial fevers,' he adds, 'the following facts seem to be established: 1. They are reasonably designated as autumnal fevers, because very much the largest number of cases occur in the Fall of the year. Spring has the next greatest number of cases. 2. They are always strictly localized in prevalence. 3. They never prevail in the thickly built portions of cities. 4. An average Summer heat of at least 60° F. for two months is necessary for their development. Their violence and mortality are greatest, however, in tropical and semi-tropical climates. 5. They prevail least where the surface of the earth is rocky; and most near marshes, shallow lakes and slow streams. The vicinity of the sea is free from them unless marshes lie near it. 6. The draining of dams or ponds and the first culture of new soil often originates them. 7. Their local prevalence in the Autumn is always checked by a decided frost.'

"Here we have the facts with regard to the symptoms and cause of the disease stated with a clearness and conciseness that could hardly be surpassed. But the real cause of the malady eluded the insight of the discriminating observers who collected those facts. A quite different class of facts required consideration. It was essential to concentrate attention on the pathological aspects of the inquiry. As to the nature of the disease, Hartshorne writes, with commendable caution: 'It is only possible to speculate at present. It is most possible that ague is a toxemic neurosis. The importance of the blood change attending it is shown by the disintegration of the blood corpuscles and deposits of pigment in various organs.' This destruction of the blood corpuscles was the critical point on which the investigation turned about 1880. Lavern, a French army surgeon, discovered the destructive agency in a minute parasite, one of the protozoa which takes up its residence in and then ungratefully enough destroys our red blood corpuscles. What a splendid problem was presented by the facts thus

brought to light. The exquisite refinement of the researches which followed may be inferred when we reflect on the minuteness of an organism which can work out a part of the life history within blood corpuscles so small that four to six millions of them find plenty of room in a cubic millimeter. But stranger still is the fact, established within the past year or two, that the mosquito plays the role of an intermediary host and transmits thê parasites to us while feasting upon our blood."

MOSQUITOES AND MALARIA.

To be brief, malaria is caused by a parasite which has two chapters in its life history: one is passed in the blood corpuscles of man and the other in the body of the *Anopheles* mosquito. A mosquito biting a malarial patient sucks blood containing one stage of the germ. The germ then makes its way from the stomach of the mosquito, through the body tissues, into the salivary glands, and from this point is injected into some other victim of the insect's proboscis. The former observations were entirely correct, but, as is often apt to be the case, the inferences were faulty. Low-lying places are malarial because they are also mosquito-ridden. Exposure to the night air does endanger one to malaria, for it is at night that *Anopheles* is abroad, seldom in the daytime.

Camphor stupefies adult mosquitoes in four or five minutes, and kills them in from four to five hours. Garlic stupefies them in a few minutes; kills them in about five hours. This explains the very old custom which is adopted in some malarious regions by those who work in the rice fields, of hanging around their necks little bags containing camphor and garlic, with the hope of protecting themselves from bad air.

The most efficient culicide is tobacco smoke; this instantly produces apparent death, and actual death in two or three minutes. In malarious places one frequently hears it remarked that "it is necessary to smoke in order not to get the fevers," which is not very far from the truth, inasmuch as tobacco drives away mosquitoes.

"The largest number of cases occur in the spring and fall", and then, too, occur the largest number of *Anopheles*. "They are always strictly localized in prevalence"—for *Anopheles* do not travel far, and so cannot carry the disease to a

great distance. "They never prevail in the thickly built portions of the city," for in such situations few *Anopheles* can breed. And so on through the whole list of observations one cannot help but marvel at the wonderful concordance.

WATER AND MALARIA.

Malaria may be carried in this way. Can it be gotten in any other way? No. It is certain that had we no mosquitoes we would have no malaria. The results of Italian investigators with respect to drinking water are summed up in the following table. Water from the worst "malarial" marshes in the world—the Pontine marshes of Rome—was used.

WATER AND MALARIA.

	No. of persons experimented upon.	Duration of the experiments. Days.	Daily quantity of water per individual.	Place from whence the water came.
Drinking	6	8-15	300-3,000 c. c.	Pontine Marshes, Ponds of the Argo.
"	12	12-21	1,000-2,000 c. c.	Valguarnera, in Sicily.
"	30	5-20	2,000-3000 c. c.	Tuscan Maremma Argo Romano.
"	25	6-24	In total, 5.24 liters.	Vallomonica, etc., in Sicily.
Inhalation air above the water.	16	2-15, twice a day; 20-30 minutes duration.	Total, 157 liters	Pontine Marshes Cervara.

And not a single case of malaria was produced. Soil from these marshes was eaten and also injected into the blood, but no malaria was caused. Men, protected from mosquitoes, slept in these districts, but could not contract the disease. However, healthy men, living in healthful districts, and taking utmost care about water, air, etc., were given severe cases of malaria when they allowed themselves to be bitten by *Anopheles* which had formerly bitten malarial patients.

No Anopheles: no malaria. No mosquitoes of any kind: more comfort, hence more health.

REMEDIES.

Fortunately, the territory concerned in this discussion is, comparatively speaking, free from both *Anopheles* and *Culex*, but they are both there, and the question is how to get rid of them. The only sane answer is, get rid entirely of the breeding places. Petroleum is useful as a palliative, but it is only temporary, is expensive if applied on large

areas with the proper frequency, and is but partially successful at the best, owing to the well-nigh impossibility of reaching all spots on a marsh for instance.

MARSHES.

The reclaiming of marshes is entirely an engineering problem, but it should be done. The Bureau of Soils (U. S. Dept. of Agriculture) has just issued a bulletin on the "Reclamation of Salt Marshes." It will be sent free to any one applying to the Division of Publication, and has a full discussion of the reclaiming process.

The summary is as follows:

"Salt marsh lands have long been considered the most fertile and valuable of lands. Practically no reclamation has been attempted in America, and that which has been attempted has in many cases been a failure or has been abandoned. There are well-established methods in use in the reclamation of salt marshes, and if these were used the work would be successful. There has never been a known case of failure to effect complete reclamation in which all proper precautions were taken. After reclamation the lands are very fertile and should repay the expenditure of reclaiming them. It is generally conceded that one acre of reclaimed salt marsh land is worth four or five acres of upland, and according to the well-substantiated figures quoted from Shaler earlier in this article, the cost of reclamation should not exceed one-fifth of the final value of the land."

So that it seems entirely feasible to drain all of the meadows in this territory at a very small final expense. There is no doubt but that this would greatly lessen the number of mosquitoes as is shown by the excellent work on Center Island.

PONDS.

Ornamental ponds, etc., had much better be drained entirely dry or filled up, but if they are retained they should be kept perfectly free of vegetation, the edges made absolutely definite and a large number of suitable fish introduced.

FISH.

The best fish for this purpose are the ordinary "minnows," as they breed readily in almost any place, bringing forth living young instead of laying eggs. The common sunfish or "pumpkin seed" is also good, but will not breed readily in many situations, are injurious to fancy fish, and

when full grown are unable to get into the shallows where mosquitoes breed. The stickleback is recommended by Dr. Howard. I would suggest that whoever has charge of the biological side of future campaigns be empowered to secure three or four ponds in which he can put a reserve of fish for distribution to property holders owning ponds or streams which are not well stocked with proper fish and which cannot be gotten rid of by draining or filling. These fish may have to be collected on the mainland, or it may be possible to successfully introduce the brackish-water forms into fresh water. At any rate, there are more minnows needed in the Long Island fresh water. *Fish and filling are the finest fighters, and of the two filling will probably win the most battles.*

DUCKS.

Doubtless ducks destroy large numbers of mosquitoes by eating the "eggboats," and possibly also the larvae. But they are by no means a sufficient remedy, especially when other and more easily obtained food is near.

FROGS.

I have found larvae abundant in small springs inhabited by half a dozen or more frogs. Hence they are practically useless.

BIRDS.

Insectivorous birds, especially night-flying species, undoubtedly kill large numbers, but they can by no means be depended on, as is shown by the fact that we have the pest in spite of the birds.

INSECTS.

Predacious insects are undoubtedly very useful. The dragon fly is a classic example. Its larva lives in the water and eats the mosquito larvæ. The adult is an excellent flyer and eats adult mosquitoes. There are other insects which are probably quite as good as some of them and might be profitably reared artificially and introduced in certain places where it is impossible to apply other remedies. An interesting instance, illustrating this point, occurred this Summer in the case of the lotus pool belonging to Mr. Louis C. Tiffany. The water was too intensely warmed during the day to allow of the successful introduction of fish. Oil

in the first application killed the lotus leaves, but subsequent oilings were unnecessary because no more larvæ appeared. Whether it was the cause or merely a coincident of this fortunate condition I cannot say, but a large number of Notonecta larvae were noticed simultaneously with the absence of mosquito larvae. Statistical observations which I made upon this insect under experimental conditions showed it to be very voracious and successful in capturing culicidal larvae.

CISTERNS, RAIN-BARRELS, ETC.

Cisterns, as far as possible, should be done away with. If retained, they should be kept constantly oiled or well stocked with fish. Where neither is feasible, it is possible to make a tight-fitting cover with a gauze-protected air-hole. These remarks apply as well to rain-barrels. Several barrels of manure water were kept free from larvae by the last method, and yet been available for gardening. Garden barrels, horse troughs, dog basins, etc., should be thoroughly sun-dried at least once a week. Utmost care should be observed in the matter of disposing of tin cans, butter tubs, etc. If they cannot be buried or dumped under a shed, they should each be turned bottom side up, or broken so that they cannot possibly hold water. Pools in barnyards should be filled up or drained. Roof spouting, where apt to be filled with leaves, needs careful attention, as do all sorts of drains. Fountains may either be well stocked with fish, or, as has been successfully done on the property of Mr. A. Heckscher, the water drawn off once a week and the basins dried. Greenhouse tanks are always troublesome, when present, unless they are attended to by oiling or fish. Saucers of profusely watered flower-pots and dishes, or tubs of water-plants form still another breeding place.

Finally, let us bear in mind that, as a rule, *every man is breeding his own mosquitoes, and every man should take care of his own property*. But with it all, in a thickly populated district, many careful people can be made to suffer by the carelessness of one. Here the community, as a whole, should take a hand, and through its officers compel the proper precautions on the part of those who will not otherwise take them.

(Signed) FRANK E. LUTZ.

Summary of conditions as to breeding places of mosquitoes in various localities examined by Professor Davenport and Mr. Lutz and their assistants.

GLEN COVE AND VICINITY.

In the densely populated part of the village the number of receptacles containing larvæ was very great. About two hundred and seventy such receptacles were counted, including 115 rain-water barrels, eighty tin cans, thirty tubs and various buckets, metal pails, old bath-tubs, boxes, coal-hods, spittoons, wheelbarrows and boats.

The points of special interest concern Glen Creek and its tributaries from the railroad westward. The upper part of this stream is a series of ponds abounding in mosquito larvae, especially below Hendrick Avenue; *Anopheles* are abundant at the sides, in the grass. Below the upper dam the water is very shallow and the streams very broad. The spot looks dangerous, but a careful examination at these points revealed few larvae. Apparently, the upper part of the middle lake should be cleaned out or filled in; but first, studies should be made earlier in the summer to determine whether larvae ever do occur here in any quantity. The lake is well stocked with fish.

Further down, on the north side of the Glen, are salt marshes with numerous *Culex*. The salt marshes on the south side were examined during the spring tides and were without larvae. Among the tributaries of Glen Creek are springy tracts and small streams entering from the north side just below Hendricks Avenue. One arises from a pond east of the railroad track that has *Anopheles*. In this stream *Anopheles* occur. West of the village are two streams arising on the lands of Elwood Valentine and Ward Dickson which have numerous *Anopheles* and *Culex*. At the corner of Coles Avenue and Prospect Street going to Mt. Barlow is a large dump-heap of tinware with countless *Culex*. Mt.

Barlow is mostly dry. Mr. Appleby has a spring that runs his ram and that contains a few larvae. There are also a few land-locked ponds around Glen Cove, as follows: Ice Pond between Forest Avenue and the station, with larvae in surrounding swamps; Golf Pond at Nassau station, with *Culex* and *Anopheles;* some ponds near house of F. E. Willets, on road from Glen Cove to Oyster Bay, with *Culex;* Frost Pond with *Culex* and *Anopheles.*

COVE LANDING TO PEACOCK POINT.

The place of Mr. Ladew had many flying mosquitoes. There were many breeding spots in pails, etc., near the stable. The spring pond on Mrs. H. L. Ladew's property and its boggy margins had many *Anopheles.* The fine spring near Mrs. H. L. Ladew's foreman's house had many *Anopheles* larvae, holes in the ground swarmed with *Culex*, and the stream in its course to the harbor swarmed with *Anopheles*, so likewise a stream rising near the house of E. F. Weeks. Northward everything was dry till the "Beach" beyond Mr. Maxwell's was reached. The salt marsh here swarms with *Culex sollicitans.* The marsh and its stream should be drained. On the east side of the marsh the place of Mr. Shaw is dangerous, *Anopheles* abounds on its grass-grown shores, and in the spring of the North Country Club nearby; also the ground around the Shaw's stable needs draining. Near the Pratts' bathing beach is a swamp with extraordinary abundance of *Culex* breeding in it. The Pratts' western stream contains a few larvae in the woods. Their "Turtle Pond" near Dosoris Pond seems to be all right—probably the abundant little hemipterous insects known as "water boatmen" *Corisa* keep it clean. The salt marsh at the edge of Dosoris Pond is full of *Culex.* The pond east of the Turtle Pond has a few *Anopheles.*

DOSORIS (OR DANA'S) ISLAND.

Pools by the road on the east side swarm with *Culex*—should be drained. Cisterns near stable are infested with larvae.

EAST ISLAND (MR. JACOBS).

The salt marsh on the west side is suspicious, but no larvae were found. The pond by the gardener's cottage is

probably kept clean by ducks and water boatmen, but the stream that supplies it and the marsh that accompanies the stream have *Culex*, at least, abundant. The salt marsh on the east side has many *Culex*.

SOUTHERN SHORE OF DOSORIS POND.

The southerly part of the drainage basin of Dosoris Pond has several very bad breeding regions. On the property of G. J. Price there is a springy tract where *Anopheles* is very abundant and *Culex* is common. This tract leads to a bad pond and a salt marsh with many mosquitoes. These require extensive draining.

Dosoris Creek, emptying into the head of Dosoris Pond, arises nearly two miles back in the hills near the road from "Dosoris" to Lattingtown. Near its source are cat-tail marshes and ice ponds with *Anopheles* abundant. Entering Pratts' woods the stream is safe. The lake in Pratts' property could be made safe by making the eastern shore abrupt. The ice pond to the north (Estate Edward Duryea) is surrounded by bad breeding places for *Anopheles* and *Culex* in the bordering stagnant, sunlit pools. On the eastern side of Mr. J. A. Young's pond are artificial pools that literally swarm with *Anopheles*. A bad *Anopheles* marsh occurs just east. Continuing along Dosoris Creek, we find cat-tail marshes, and finally salt marshes in the property of Percy Chubb, M. H. Ham and Mr. Simpson respectively. The salt marshes have *Culex* common.

LATTINGTOWN SWAMP.

The western arm of Fox Island Inlet is supplied by three streams. One arises in the midst of Lattingtown, runs behind the the church and then to Mr. Guthrie's place. This has abundant *Anopheles* and *Culex*. The second rises southeast of the Pratt mausoleum in a *Culex* bog and in springs. *Anopheles* and *Culex* accompany this branch to Mr. Guthrie's place. The third branch comes from the southeast, and supplies Mr. Guthrie's ice-pond. *Culex* and *Anopheles* abound in its upper reaches. The duck ponds in Mr. Guthrie's place contain many *Anopheles*, and certain imperfect drains and much of the plowed ground at the time of inspection were breeding many *Anopheles*.

UP GLEN CREEK VALLEY FROM THE RAILROAD CROSSING SOUTH.

A pond just south of the track is infested with larvae, and *Anopheles* also occur, although sparsely, in the marshy woods south. Pools at the Sea Cliff road-crossing (Edgar Duryea Estate) have *Anopheles* common, and should be drained. On the hills to the west, in the land of Mrs. Samuel Craft, is a swamp with *Anopheles* and *Culex*. This should be filled. In the valley along the stream numerous breeding places are found in De Witt Valentine's place (*Anopheles* abundant). The pools in Edmund Price's land should be drained. The stream ceased here at the time of inspection, but springy ground, with *Anopheles*, is found in the property of Mrs. Caroline Price, Mr. Watt, J. Mathews, G. H. Townsend, S. J. Simonson, C. R. Simonson, H. G. Duryea, W. H. Simonson, Mrs. Mary Seaman, Wm. J. Willis and John Sherrard. Continuing along the valley road toward Greenvale, one finds, in addition to the usual barrels and drinking-troughs about farm-houses, a few dangerous springs and ponds, especially on the land of T. F. Bailey and Mr. Richard Underhill.

SEA CLIFF.

Sea Cliff is on a high and dry hill. Drinking water comes largely from cisterns, and of these there were some thirty which were found to be infested with larvae and some hundred more which probably bred larvae. Adult mosquitoes are said not to be very troublesome as a usual thing, but Mr. Bennett reported about a dozen *Anopheles* in his room on one night in September. He found also a few *Culex*.

EAST SIDE OF HEMPSTEAD HARBOR FROM SEA CLIFF TO ROSLYN.

Starting at the brick engine-house at the base of the hill, the trouble is all on the left hand side—a *Culex* marsh by the bath-houses, a salt marsh running back to the land of Mr. W. A. Isaac, which contains pools with *Anopheles* and *Culex* common. Just south of the "Children's Settlement" is a swamp fed upon by abundant *Anopheles*. Beyond, the stream by the roadside (Townsend Scudder) has *Anopheles* abundant and should be drained. Mr. Scudder's garden pond has many *Anopheles*. His pump back of the garden and his cow-pond in the back lots

are breeding spots. The ponds by the hotel at Glenwood Landing have many larvae. Glenwood Creek is dangerous. The lower pond has *Anopheles* present at its edges. The land of John Townsend above requires extensive draining. Ayer's Landing Creek is very dangerous. The worst places are on the land of T. Chapham. Here near the north of the creek are marvelous springs with abundant *Anopheles*. Extensive draining is called for here. Above, in the land of Sutton Mott and E. Duryea, there are dangerous spots along the stream and near its headwaters. Just south of the mouth of Ayer's Landing Creek, on the land of H. H. Hoggins, are some ponds in a ravine. Their edges are badly kept and support numerous *Anopheles*.

ROSLYN.

We begin one mile north of the village on the Shore Road. The stream that empties into the harbor at A. Ward's place arises in *Anopheles*-infested springs in the land of Mr. Goddard, and even eastward. It has boggy edges (*Anopheles*) in Mr. Ward's place, east of the Shore Road. The pond near the house has *Anopheles* abundant. On the east side of the Shore Road the ponds near Gen. Lloyd Brice's new house have *Anopheles* common. On the west side of the road the small ponds of A. L. White have *Anopheles* abundant, so likewise the ponds on the adjoining property of Mr. Duncan. The larger lakes seem to be fairly free, but should be cleaned and stocked. The two ponds near the road, on the west side, have *Anopheles* abundant, and should be drained or stocked. From the southernmost of the four lakes to J. Hennesey's stable, in Roslyn, the conditions are frightful. A clay stratum outcrops here, and a sheet of spring water forms bogs and rivulets that trickle among numerous tenement houses. *Anopheles* and *Culex* occur in great numbers. The streams form open sewers for the upper row of houses and water for household purposes for the lower row of houses.

Continuing south, nearly the entire source of mosquitoes is along the three lakes. The edges of the lakes have a few *Anopheles*, but the boggy ground and springs have them common to abundant (especially Mr. J. Conklin's spring and his barrel sunk in the upper lake). At the head of the valley we rise above the clay stratum, and are not troubled by springs.

The condition on the west side of the lakes is not quite so bad as on the east side, for the drainage is better. There are a few drainage pools on top of the hill, but they did not seem to be breeding mosquitoes at the time of inspection.

The west shore of Hempstead Harbor is less springy than the east. There are six or eight mosquito-breeding points. The salt marsh at the head and on the west side of the harbor was flooded by spring tides, and contained no mosquitoes.

That part of Roslyn that lies east of the railway station contains numerous cisterns and rain-water barrels, breeding larvae. The place is in need of inspection by a health officer.

HARBOR HILL. (C. H. MACKAY.)

The pond by the stables (fountain) has *Anopheles* common. Some of the catch-basins for the gutters hold water containing larvæ. Drainage pools near the stone bridge, northeast of the new house, contained many *Anopheles* and *Culex*. In the northwest corner of the block, pools near manure piles in the orchard had *Culex* abundant; two pools near railroad track had *Anopheles* and *Culex* common, and a pond near the intersection of the railroad and Tilford Highway had *Anopheles* common.

OYSTER BAY, COVE NECK AND NORWICH.

Here were noted the two ponds of President Roosevelt and Dan'l Smith. Wm. Young's pond was free, as elsewhere stated, but the stream and connected ponds belonging to Mrs. John Underhill and Van Wyck estate contain *Anopheles*. Frank Underhill, in Florence Park, has three ponds all in bad condition. In Oyster Bay village the stream along Maxwell and Larrabee Avenues, the spot back of the Hook and Ladder House, owned by Mr. Townsend, the fresh water marsh near railroad, with its connections, and the tank under the post office, each contributes its share. *Anopheles* were found excessively abundant just above the Electric Light Pond by John Cody's house. A few were also found in the pond itself in the aquatic vegetation. The Oyster Bay Board of Health would do well to take up this matter officially, as throughout the village complaint about standing water was general. On the hill southeast of Oyster Bay *Anopheles* were found on the properties of Camille Weidenfeld, the Golf Club, Thomas Bailey, the vacant property for which Richard Downing of East Norwich is agent, and that

of Patrick Callan. On the road from Oyster Bay to East Norwich *Anopheles* were breeding in the pool near Geo. Ranlose's property and the stream which runs along the road throughout its course to its source in the three pools in East Norwich owned by Mr. Frost, also in the small pool in front of the blacksmith shop. Going back again, *Anopheles* were found at the head of G. W. Beekman's pond and in the partly drained marsh below, in all three of the mill creek ponds, as well as in the still reaches of the connecting and inflowing streams, the pond of J. D. Weeks which connects with the lower pond, P. Ingram's pond, and in several places in the source streams, *e. g.*, near Willet Hick's.

COLD SPRING AND VICINITY.

No *Anopheles* were seen on Lloyd's Neck, but there are several excellent places for them if they were introduced, *e. g.*, the duck ponds and stream on Richard Derby's property. *Anopheles* were abundant about the Hammond brickyard, even occurring in situations usually given over to *Culex*. The Robert De Forest pond and the connecting drains and streams are ideal places from the standpoint of *Anopheles*. In fact, they were found there in abundance, as was also malaria along the whole course. The cress run of Wm. Jones and the edges of the three lakes, where fish could not or did not get, come within the list, as also did the water along the side of the road near Cold Spring station. The pond formed by the old embankment west of the second lake is exceedingly dangerous, but fortunately there are not many houses near. One of the unstocked ponds on the grounds of the New York Fish Hatchery contained *Anopheles*, and the pond by the schoolhouse was badly infested by the larvae. The ponds on Dr. Jones's property, golf grounds, and those of Geo. S. Brighton, the Van Wyck estate, and Mrs. Samuel Jones bring us to Cove Neck.

LOCUST VALLEY AND VICINITY.

Anopheles were abundant at the foot of the D. H. Remsen pond and in the head of the stream near Chas. E. Nelson and R. G. Clark. *Anopheles* were found also in the ponds on the places of Peter Cox, Chas. Firling, the Lewis pond and stream above, Townsend Cox, Benj. Craft, Frost Pond, John Young, T. F. Bailey, Thomas Underhill, A. A. Price and Mr. Van Cott.

Report by Prof. N. S. Shaler, of Cambridge, Mass., on the Marshes and Swamps of Northern Long Island, Between Port Washington and Cold Spring Harbor.

The object of this report is to set forth the conditions of the marine marshes and fresh-water swamps in the towns of North Hempstead and Oyster Bay, with special reference to the methods by which they may be prevented from being the breeding places of mosquitoes and at the same time be made profitable as tilled fields, or at least unobjectionable features in the landscape. Although this presentation of the matter will demand some consideration of the processes by which these marshes and swamps have been and are now forming, no further account of them will be given than is necessary for the discussion of the ways by which they may be improved.

CLASSIFICATION OF AREA TO BE TREATED.

As is suggested by the title of this report, the inundated lands of this district are by their nature divided into two groups, those termed marshes, which lie below the level of high tide and are more or less completely flooded and bared twice a day, and those known as swamps, which have their surfaces above the tidal level and receive their water from the land. The conditions which have led to the formation of these two classes of wet lands may be briefly stated as follows:

The existing marine marshes of this coast began to develop at a time geologically very recent, when the level of the sea along the shores of all the continents was considerably and rather suddenly raised to the extent of a hundred feet or more. The effect of this action was to form a new and very indented shore line; wherever there was a bay so small that the wind could not produce waves more than about two feet high, certain marine grasses and other plants fitted to live with their roots in salt water began to grow there and

formed a tough mat—the turf of the marine marshes. This sheet of vegetation grew outwardly from the shore as fast as the accumulating sediments shallowed the water to the point where they could obtain a footing. Thus in time the bay became a marsh, occupied by vegetation, except where narrow creeks were kept open by the swift movement of the water as it flowed in or out at each tide. The number of these embayments sufficiently sheltered from wave action to permit the growth of marsh vegetation, at first rather limited, was in time greatly increased by the formation of barrier beaches such as form in great storms when the waves break at some distance from the shore line. Nearly all the marsh area in this district has been formed in such shallow lagoons, locally known as salt-water ponds.

The fresh-water swamps and swampy parts of the area we are considering owe their origin to diverse actions. In part they are due to the above-mentioned rise of the ocean level, which hindered the passage of the land-water to the sea, with the result that swamps grew up on either side of the streams. In larger part these swamps are due to the construction of mill-dams across the brooks. Around the margins of these pools fresh-water plants create a mat of vegetation which extends outwardly over the area of the pool, substantially in the manner that it does in the process of growth of the tidal marshes. A third and more common group of swampy deposits is found in the numerous depressions of the glacial drift which covers all this field. Near the shore these pits are comparatively rare, for the reason that the drift deposits in that section are generally plains or sand-hills. Beyond these plains to the southward lies the main glacial moraine, which rises to the height of between three and four hundred feet above the sea. This deposit consists of confusedly intermingled clay, sand, pebbles and boulders; its surface form is exceedingly varied, there being very numerous pit-like depressions, many of which hold water throughout the wet summers; they are frequently the seats of small swamps that do not ever become dry. Although the greater part of these morainal fields lie so far from the shore that the small bogs they contain are not harmful to the people who dwell along the coast line, certain outlying patches of this nature come near to tide-water about Oyster

Bay and near Roslyn, and will have to be considered in the project for betterment.

Yet another group of wet lands which will require attention is made up of the strips of ground along the shores just above high tide, where the rain-water from the beds of sand and gravel escapes to the sea. In general this water does not emerge as distinct springs, but in a seeping manner, so that it forms small pools, having an area of from a few square inches to some square feet in area. Although this mode of outflow of the land-waters is so common that it may be considered as universal along these shores, it is where the coast line is low and sandy, so brought about, that no pools formed. Probably not more than one-tenth of the shore line will on this account have to be cared for.

In addition to the natural reservoirs of still water, which are or may become the breeding places of mosquitoes, there are, besides the mill-ponds, very many artificial pools and vats about, which because of their nearness to the dwellings are as objectionable as the remoter swamps and marshes. These will have to be dealt with before the end can be attained.

CONDITION OF THE MARINE MARSHES.

In considering the ways by which the wet lands of this district may be improved, the order of arrangement given in the foregoing classification of the areas will be followed. As to the first group, that of tidal marshes, it is well to note the fact that they are in diverse states of growth. Where, as at Dosoris Pond, the area has, by the recent formation of barrier beaches thrown up by the waves, been but a short time in the condition which permits the free growth of marine grasses, the deposits consist mainly of mud and sand, with but a fringe of turf. Such areas do not as yet demand any treatment except it may be some filling of their higher marginal parts, when the rain-water or that seeping from the banks may make breeding places for insects.

More advanced in development than the very imperfect Dosoris marsh is that group of three such areas lying between Peacock Point and Fox Point. The westernmost of these, that on the estate of Mr. Guthrie, now diked from the sea and drained, was nearly complete before its redemption was undertaken. The middle section, that on the estate of

Mr. Cravath, is in an intermediate state of growth, a considerable part of the surface still being without the characteristic turf and covered by water at low tide. That farthest to the eastward, though somewhat nearer completion, is still imperfect. The other fields to the eastward are more like that at Sands Point, in that they are nearly full grown, about all the surface barred from the sea except the creeks, which afford passage for the tidal flow, being turfed.

Besides the distinctly enclosed marshes above noted there are several fringe-like strips of this nature which border the larger bays. The most noteworthy of these occurs on the west margin of Hempstead Harbor, north of Roslyn, and on the southern border of Oyster Bay, near the village of that name. These areas represent the effort of the marsh-making vegetation to take possession of waters so broad that the waves disrupt the turf nearly as fast as it forms. That near Roslyn is of recent origin, its formation having been made possible through the growth of the remarkable sand spit known as Bar Beach, which finds the inner part of the harbor from the waves of the Sound.

METHOD OF TREATMENT OF THE MARINE MARSHES.

The end which is sought can commonly be obtained by treating the marine marshes in either of two diverse ways, in the one by diking them from the sea so that they may be entirely drained and tilled, and the other also by diking with an arrangement of flood gates so that they may be kept constantly full to the level of the spring tides with salt water. Either of these methods will aid in the desired result. If the areas are kept fairly dry there will be no places for mosquitoes to breed; if covered with water which is about half as salt as the sea, some evidence goes to show that extensive breeding will not take place, though some authorities are of different mind. I shall now discuss the relative advantages of these methods and their applicability to the several areas.

Where, as in the case of Dosoris Pond, the growth of the marsh is at the beginning, and the surface bared at low tide relatively small, the most satisfactory plan will be to dike the sea-water in. It may be said, however, that because the tide sweeps over this area freely, the only breeding places are around the shores near high-tide, in the chance pools, where

the water becomes so brackish that the insects may develop in it. It will probably be less expensive to fill these pools and to watch lest they re-form than to reclaim the whole field. While it is true that this "pond" will gradually be converted into a marsh, it will be many years before the surface of the deposit will rise so high that from spring tide to spring tide the pools it encloses will ever become so far brackish that insects will breed in them. The middle and easternmost of the marsh area lying between Peacock Point and Fox Point can be drained and brought into cultivation, but the expense of filling up the considerable pools and of keeping the surface even during the term of years in which settlement of the deposit due to the decay of the vegetable matter it contains, will make it cheaper to retain the sea-water. It is possible that a close estimate may show that this will also be the case in the marsh at Mosquito Cove near the village of Sea Cliff.

It may here be noted that the method of retaining the sea-water at high tide on the marshes may often be so applied that a small but fairly deep boat harbor is kept open at the place where they discharge into the sea. It will in practice be found necessary to allow the impounded water to flow out once a month, just before the time of highest tides. By permitting this discharge to take place when the sea is low the mouth of the creek will be scoured to a much greater depth than by the natural ebb and flow. It may, however, be necessary to aid this process by constructing fillies so that the excavated material will be discharged into deep water and not form an outer bar, and to avoid the entrance of sands running along the shore which may tend to fill up the harbor in the interval during which there is no current through it. To secure any considerable depth of water some dredging work would be necessary.

In case it is found that the water retained in the marine marshes becomes excessively freshened by the influx from the land during the intervals of about four weeks between the higher tides, it will be possible at no great expense to increase the proportion of salt to the required amount by pumping in water from the sea. This could readily be done at small cost by means of windmills or other engines. It does not seem likely that in the case of any of the marshes of this field which it may prove desirable to flood the

influx of land-water even in years of the heaviest rains will be serious. The principal disadvantage of the above-noted method of flooding is that the marshes thus treated can never have any economic value and are apt to be unsightly. They might perhaps be stocked with certain kinds of fishes, but the monthly draining down of the water would probably make this impracticable. In general it may be said that it is best to reduce them to tillage.

Where it is determined that it is better to drain the marshes and reduce them to tillage, the steps to be taken are, in general, as follows:

First, it is necessary to ensure that the area may be securely protected from access of the salt water. The particular methods to be adopted in each case should be determined by engineers. This work will not be difficult or costly for the reason that the waves from the Sound have far less energy than those from the open sea. In determining the site of the dam, it is important to bear in mind the fact that it is necessary to provide storage room in the diked area for the water which in times of heavy rain may have to be retained for the six hours or more during which the tide is higher than the drainage area of the marsh. In most instances the dam can be so placed that the larger part of this water may find room in the channel of the creek by which the tide enters, thus lessening the amount of excavation required to provide such storage.

In those cases where the marsh is of the complete kind, *i. e.*, where the turf lies evenly at a level of about a foot below high water, the next step is to provide drainage for the field. This should be effected by the use of tile drains leading to the fewest possible open channels; for the end in view it is desirable to altogether avoid such open channels, for the reason that because of their necessarily slight slope they are apt to hold water. The spacing of these drains and the slopes of the pipes are matters to be determined by engineers according to the conditions of each area. It may be said, however, that the pipe drains should not be of the glazed kind: the unglazed are cheaper and more serviceable.

The next step in the redemption of the marsh—that of breaking the sod—should be taken as soon as may be after the area has been partly dried out. If the salt water is excluded in the Spring the field will commonly be ready for

breaking not later than the following Autumn. Wherever the sea is diked out it is for the purpose of the work in hand absolutely necessary that the ground be quickly reduced to tillage for the reason that if it be left without care a host of strong-growing annual land plants will at once take root there, and by their matted vegetation retain enough water to serve the needs of insects. In a year or two many bushy perennials and certain trees, particularly the white birch, will abundantly develop, forming a dense swamp growth, which will nurture not only the common mosquitoes, but the malaria-bearing anopheles as well. Though the *Anopheles* appear not to breed in the pools of salt marshes to a dangerous extent, the effect of diking these areas without tillage would be to increase the danger from this pest.

In plowing it is necessary, or at least most desirable, completely to break up the layer of living turf. As this layer is usually about ten inches in depth, and of a very tough nature, it is difficult to affect this by means of horsed plows, though it can be done in that way. The better plan is to use gang plows drawn by stationary steam engines placed on the firm ground on either side of the marsh, the traction being applied through wire ropes running over movable snatch blocks. This method of plowing is costlier than where the work is done with horses, but is much more efficient ; by its use not only can the turf be broken to the base of the living roots, but a part of the richer muck which lies below can be mingled with the spongy layer.

When the marsh has been plowed it is then necessary to leach out the excess of saline matter which it contains, so as to bring it to a state where it will permit it to be cropped This is easily done by allowing the land-water during the Winter season to cover the area, draining it away as soon as it has soaked out what it can readily dissolve. In an ordinarily rainy season it is usually possible to carry this leaching to a point where the field can be tilled. If this course be not taken the salt in the soil will continually work upward in such quantities that a crust of it will form on the surface and the tilled layer be unfit for cultivated plants. In some cases where the supply of land-water is limited, as, for instance, in the marsh near Plum Point, it may require more than one Winter to effect this leaching. The end may be obtained without flooding through the leaching action of the

rain alone, but the process will be relatively slow, and may require a number of years for its completion to the point where the field may be cropped.

It is always found that the turf or spongy top layer of the marsh is difficult to destroy. Efforts have been made to burn it, but until it has lost its salt this is practically impossible, and in any conditions a task of much difficulty. It may be removed and stacked on the sides of the marsh, or as heaps in the field, but this is costly, the expense being from seventy-five cents to one dollar per square rod; moreover, the heaps are unsightly. On the whole, the best plan, when the field is to be planted in other crops than cranberries, is after the necessary leaching has been effected to harrow the field with a *rotary disc* harrow, and again plow it to a greater depth than before, so that the clay-like muck may, as far as convenient, be mingled with the spongy turf—a process which increases its fertility and hastens the rotting of the wire-like roots.

Of the numerous tracts of marine marsh lying within the field considered in this report, there are three which are especially well fitted for winning to tillage or to use as meadows. There are the large area on Manhasset Neck, on or near the property of Mr. Howard Gould, that of Mr. Guthrie, near Lattingtown, and that on Center Island, north of Plum Point. All of these marshes are so nearly completed that they will require but little grading to make them ready for the plow. They are, moreover, so placed that they will receive but little water from the neighboring highland, and can thus easily be brought to the desired state of dryness. The area on the property of Mr. Guthrie, near Peacock Point, needs but little expenditure to bring it to a state in which it will be fit for use.

AGRICULTURAL USES AND VALUE OF DRAINED MARSHES.

The fertility of fields which have been won from marshes is of the highest order, and their endurance to cropping without manuring much exceeds that of any other tilled lands except it may be those in certain arid districts which have been irrigated. The range of crops for which they, if not at once, yet in time, become fitted is likewise great, including all our ordinary crops of farm and garden, except in

some places Indian corn. For truck farming they are peculiarly well adapted, for the reason that it is easy to maintain the level of the earth's water where the roots of plants can have access to it. The value of salt marshes for tillage may, in general, be shown that the larger part of the best arable land in Holland and much of that in Belgium, Northern Germany and Eastern England has been won from such originally tidal fields. The total area thus gained from the sea has never been carefully estimated, but from a knowledge of those countries I am convinced that it cannot well be less than ten thousand square miles, and its productive value much exceeds that of the best uplands of this country.

The only large example of the diked and improved marshes on the northeastern shore of the United States is that at Green Harbor, Plymouth County, Massachusetts. Here the conditions as regards the nature of the turf and subjacent material, as well as the height of the tide, are measurably the same as about Oyster Bay and Hempstead Harbor. Of these Green River marshes, about twelve hundred acres have been won to tillage, about one-half being used for hay-fields, which are occasionally plowed, the other used for varied crops. The yield of hay of excellent quality averages rather more than two tons per acre : it is, as experiments show, preferred by animals to that grown on higher ground. The soil appears to be admirably suited for all the plants raised on truck farms, the crops being more abundant and maturing somewhat earlier than elsewhere in the same district. Asparagus has produced large crops continuously for more than twenty years without the use of any manure or other fertilizers. It is reckoned by Mr. Edmund Hersey, of Hingham, a very competent expert, that on his fields of asparagus there had been expended $600 for fertilizing in a score of years, or at the rate of $20 each year. This long-continued exemption from the need of manuring is of itself to be reckoned as a feature of great value which is found in no other lands except marine marshes and certain irrigated lands in arid regions.

In the Green River marshes cranberry bogs have been extensively planted, and the yield both as regards quantity and quality has been very satisfactory, the annual profit being not less than that won from the plantations formed on fresh-water swamps where with ordinary care it may be

safely estimated as exceeding $100 per year for each acre. Other garden crops, such as onions, have succeeded on the Green River reclaimed lands quite as well as those above-mentioned. So, too, Indian corn has yielded excellently on the dryer part of the area. Not the least of the advantages of these marsh lands is that they are much less likely to be visited by frosts than are the higher grounds. This relative immunity is due to their nearness to the sea and to the protective effect of the weather and the fogs that come from the open water by which they lie.

In reckoning the money value of marsh lands, the estimate should be made with reference to their use for market-garden purposes or for other uses than meadows. While it is well ascertained that they will yield abundant crops of hay, it will probably not be found advantageous to convert them into meadows for the reason that in wet seasons, or by the chance clogging of drains even in those which are dry, the thick-set growth will tend to develop and conceal pools of water which may remain long enough to become breeding places for insects. Where for landscape effect a permanent coating of vegetation is desired, the field, if the conditions admit, should be planted in cranberries. In this form of tillage the surface after the first year is completely covered by the plants, the hues of which, though varying with the season, are always beautiful. To make sure of a profitable return from such fields, it is, however, necessary so to arrange them that they can be flooded with fresh water during the Winter and flooded once again for a day or two in April, after they have been exposed for a week or more to the air. To effect this temporary flooding it is necessary to have access to a considerable stream of water which may be led onto the bog, or to have a reservoir for that purpose on this account. The only marine marshes suited to such plantations within the limits of the field we are considering are those near the mouth of Mill Neck Creek, a small area near the head of Dosoris Pond and that at Mosquito Cove. It should be noted that because the cranberry is by nature a swamp plant it can be grown on marshes which lie at a somewhat lower level than the average of such deposits, it will yield a profit on ground rather too wet for ordinary market-garden use. My preliminary inspection indicates that probably about a hundred

acres of the land to be drained will prove well suited to this industry.

As to the economic value of the improved marine marshes, it may in general be said that, owing to their exceeding fertility and relative immunity from the effects of droughts, they may fairly be valued for tillage in high-grade crops, such as market-garden produce, as worth per acre not less than four times as much as the richest high-lying lands in their neighborhood. I have already noted the fact that in the case of the asparagus culture at Green Harbor, Mass., the sparing of expense for manure, not counting the labor of applying it, was at the rate of $20 per acre each year. This saving of itself is sufficient to give such ground a far greater value than the best uplands.

The cost of bringing the marshes of this district into a fit state for tillage, including all the work of diking, draining and plowing, should not, in my opinion, exceed on the average $150 per acre; for other crops except cranberries, where because the turf will generally have to be removed, it will be near twice that sum. This is, however, but a rough estimate, and should be verified by the study of engineers. In their present condition these marshes produce only a little coarse hay from their native grasses. The profit on this product probably does not on the average amount to two dollars per acre per annum. This low return is in part due to the fact that some of the areas are so incompletely occupied by the grasses that they are not mowed at all. The average value of these lands, based on the returns they give, does not in their present state exceed $20 per acre.

METHOD OF TREATMENT OF THE FRESH-WATER SWAMPS.

So far as the fresh-water swamps lie along the brooks, as those by the side of Mill Neck brook, the method of treatment is simple. The waterways need so far as practicable to be straightened; the existing dams, once serviceable for the use of mills, but no longer so, should be removed. The beds should be deepened and the banks made steep, so that the water will be kept in motion at the rate of at least a mile an hour. The alluvial ground should be made level, and if not so low and flat that there is danger of the water stag-

nating, may be used for meadows. If this risk is evident, they should be planted in cranberries, for which they are well fitted. The areas that need such treatment are limited, probably in all not exceeding seventy-five acres. If the damages, in fact almost nominal, arising from the disuse of the mill-ponds are neglected, the cost of such improvements apparently need not for equal areas much exceed that demanded in the case of fresh-water swamps. The expense can be adequately determined only by a detailed estimate.

There remains for consideration the pools and swamps, mostly small, which lie in the hollows of the glacial drift. The greater number of these lie so far south of the shore belt that they are not likely to affect the people dwelling near the sea. There are, however, some of these bogs near enough to the shore to demand attention, and in time it may be found desirable to improve them all. In most cases the extent of these deposits is so small that it evidently will not be worth while to convert them into tilled fields. Where the conditions permit they should be drained to such a depth that even where they become covered with bushes they will not retain water. The smaller of them, those which generally are lodged in deep pits, should be filled to such a depth that they will not remain dry. In many instances it will be found that the best plan will be to make the filling with the largest obtainable stones, so that in their interstices there may be room for storing the water which finds its way into the pit. It will often be found that the ponds in these depressions are held in by a thin-puddled layer on their bottoms, which, if broken through, will afford a free passage to the porous gravel below. So far as this means of draining proves effective, the remedy will be of trifling cost ; in any event, the expense will not be serious.

IMPORTANCE OF THE WORK.

Having now set forth the conditions of this undertaking, it may be well to note the importance to the health and comfort of the people who are to be affected by the changes which will be brought about by its completion. First, as to the species of commoner mosquitoes, the culex of naturalists. It may be said that they alone are at once a serious inconvenience and a source of some decided injury to health. In order to exclude them by means of netting, the houses,

especially in their bedrooms, are often deprived of proper ventilation. Out-of-door life, the very foundation of well-being, is made uncomfortable in the season that most tempts to the open. Whatever expenditure may serve to rid the people of this serious nuisance, if not inordinately costly, even if no other advantage was to be gained, would be warranted. Recent inquiries, however, have made it evident that certain less common species of mosquito, known as *Anopheles*, are the agents by which malarial poisons are transmitted. The evidence on this point, which at first seemed doubtful, has, within a year, been so accumulated that there is no longer room for doubt as to the fact that by far the most common, and probably the only means by which the various forms of intermittent fever, including the ordinary ague, is communicated, is by these insects.

So far as I have been able to ascertain, ague and fever did not exist in the region about New York fifty years ago. It appears to have migrated here from the South, and to have extended up the Hudson Valley, afterwards up that of the Housatonic, thence to Connecticut, and eastward through Central Massachusetts to the neighborhood of Boston, where it appeared about ten years ago. When the insect appears in any district, it appears to spread slowly, occupying one station after another, requiring many years before it becomes a common inhabitant of the pools. The facts gathered by the entomologists seem to indicate that as yet it has not attained to anything like its full extension in the district between Hempstead and Cold Spring Harbor.

My inspection of this field showed that the betterments already undertaken have been well planned by your engineer, and begun in a way which promises to attain the end in view with the least possible expenditure. They have already gone far enough to afford a fair basis for computing the total cost of the work. If carried to a finish and adequately maintained, they bid fair not only to relieve this admirable district of its pests, but to make it the first instance and example of a kind of work which is to be of great benefit to mankind.

N. S. SHALER.

October, 1901.

Detailed Engineering Report, by Henry Clay Weeks.

Having considered in the general report the varied kinds of water surfaces, we now take up a treatment of the larger ones in detail, following the shore, beginning at the West. Those requiring a short description will be found in the Indexed Report—those requiring longer explanations, follow here :

SANDS POINT.

Inasmuch as the Association's outline of plan proposed "the treatment of the fringe of adjoining territory in each direction," an examination was made of the western shore of Hempstead Harbor, as far as Mott's Dock, also east of Sands Point Light. Some cooperation is necessary in this quarter to entirely relieve the section east of it, for the reason that winds from the westward might occasionally bear a brood to the Glen Cove section.

No examination was made of the interior of Manhasset Neck, but at its most northern end—at Prospect Point—there is a salt marsh, with the customary tidal creek coursing through it. An elevated peninsula (at one time a complete island) lies in front of the marsh. Between the two ends of the peninsula and the mainland there has been built up, by the action of the sea, a barrier of sand sufficiently high to prevent the tide overflowing it, except perhaps in extraordinary high tides. Against these it might be necessary to provide in case the marsh land is to be cultivated. A narrow outlet to the tidal creek is maintained through this barrier by the movement of the tides. This outlet is comparatively a small one, and that fact makes the reclamation of the marsh within a simple and relatively inexpensive matter, when the acreage is taken into consideration. Throughout, a number of marsh pools exist. Such pools are always prolific breeding grounds of *Culex*.

The treatment recommended for this marsh, is that a ditch be made, running southerly from the mouth of the

creek, from which an easterly and westerly branch be made. On account of the small watershed of this marsh, the ditches need not be large. The creek would better be closed at its mouth by an automatic tide-gate, and this area would shortly be in a condition dry enough for cultivation.

An examination was not made of the depth of the marsh soil, but judging from a casual look over the situation it is probably at least four feet deep. This indicates somewhat the value of this marsh for cropping. The cost of this work, approximately, would be $2940, considerably less than fifty dollars an acre

WEST SHORE OF HEMPSTEAD HARBOR.

Along the west shore there are but few places requiring treatment, on account of the steep banks. The only places of any size are the two ponds referred to in the indexed report. Some water from springs below the road which skirts the bank will require opening out to prevent settling in pools.

ROSLYN.

Here we find a decided variation from the usual contour. This is the only vlei into which no streams enter from the south. Tableland about 150 feet in elevation is immediately at the southern end of the village. So we have no continuous inland creek to provide for. Almost all conditions are highly favorable to a scheme of extermination. The only exceptions are the three mill-ponds, in the midst of the village, fed by very active springs, on which they entirely depend for water, and which now form bad streams and pools in the brush at the sides of the ponds and marsh. Nearly all sources of supply are about at the level or beneath the level of the water of the lakes. This water area and its surroundings meet all the bad conditions mentioned in the general statement of this report as to typical unused mill-ponds. In fact, some of the features there described might here truthfully be amplified. It is recommended for these lakes, that they be drained, under the limitations expressed in the General Engineering Report, their area cleaned up and cultivated or in time built upon, if the idea of a park as heretofore outlined is not feasible. The improvement which a park would give to this village is far beyond anything that is pictured elsewhere in this

report—in fact, no words could adequately describe the sanitary, material and scenic result that could be attained.

Inasmuch as William Cullen Bryant took the initial in the Central Park movement, New York City, showing a great interest in relieving a bad situation as well as in providing a place of beauty for popular use, and Roslyn was his dearly loved home, the park might be given as a memorial name, "Bryant Park," and the old paper mill visited by Washington be preserved—thus outside aid might be had for some of the public buildings. An alternate scheme could be carried out similar to the one recommended for Glen Cove.

It is recommended further that the salt marsh area be diked off as far to the north as possible, say to the mouth of the creek where the marsh is covered at high water, and that the present creek be used as a canal up to any docks south of it which may have to be maintained. This canal should have on its sides a dike to shut off the waters of the bay. At the southern end of this canal should be built a tide-gate, which would let out the interior water but exclude the waters of the bay. From the tide-gate still southward there should be an open ditch, connecting with the outlet of the present ponds. The marsh area which thus would be reclaimed should be cleaned up and cultivated or used for building purposes, thus giving additional area to this section, confined as it is. The springs and streams which enter the marsh area from both sides must be opened up for free flow.

The cost of such a work would largely depend on the extent of improvement decided upon, but, aside from house drainage, decorative or farm work, it is estimated that the cost would be $15,350.00.

NEAR STEAMBOAT LANDING, ROSLYN.

Following along the east shore of Hempstead Harbor, a stream from the uplands enters the bay just north of the steamboat landing. At points, this stream widens out into ponds (two are at the rear of the house of R. A. Ryley), and by its not being confined within banks keeps large spaces saturated, all parts making excellent breeding grounds. The length of the stream is about 3,500 feet, and it should be straightened and graded to sharp banks, and necessary lateral open drains made. The descent is sufficieut to make a rate of current prohibitive for breeding. The cost is estimated at $375.

NORTH ROSLYN.

East of the railroad, about a quarter of a mile south of the stone road, are a number of ponds on the grounds of Mr. C. A. Mackay. Those nearest the track are formed by the railroad embankment built across a ravine. The culvert under same has become filled up, and the east mouth of it is now buried by accumulations. These ponds could be eliminated by opening the culvert again and keeping it open. The other ponds could be drained out into the ravine or easily filled. This work could all be done at a trifling cost.

THE GLENWOOD SECTION.

First comes the Clapham pond and marshes. Until total reclamation is effected, the marsh to the west of the road would require but little done to it, on account of the tide entering strongly there, but some springs to the south, whose waters on both sides of the road enter this marsh, need to have their courses freed, at a cost of about $50.00. A little mill is occasionally run by water from the Clapham pond, otherwise this pond and wet area of about four acres answers no purpose other than a fine breeding place. The outlet under the macadamized road should be lowered and widened sufficient to take off the heaviest spring rains and the waters rising above there, and an automatic screened gate inserted on the outer side. The pond sides should be cleared up of brush, and small drains made to carry down spring waters. The whole area now of water and brush could be made into a fertile spot and pay for its redemption, which would cost about $650.00, part of which should be borne by the road authorities. The jungle above the Clapham pond belongs to Mr. W. R. Willetts, and was at one point formerly an old mill-pond, but the dam is broken through and the water is largely run out. Enough, however, remains and comes from above to keep a large space constantly wet. This space should have a large central and lateral drain dug and the brush cleared out. The main drain should run back to head waters about 1,200 feet distant, thus relieving a broad space of saturated land at that point. The cost of all would be about $850.00, and would well pay in good land reclaimed.

AT GLENWOOD LANDING.

When the splendid boulevard was constructed along this shore the builders did not engineer for mosquitoes. By

too great elevation of culverts, ponds were purposely held within the road, with no thought that they would become points for breeding mosquitoes, but they do it most effectively, as physicians and others testify. Here, again, the culvert is required to be placed at a lower level and a tide-gate fixed to exclude tide-water. A connecting drain 520 feet long should be run eastward to the ice-pond of Geo. H. Townsend (facing Seaman's store). This pond should have the outlet fixed so as to drain it all off in the Springtime as suggested elsewhere, provided it is to be maintained as an ice-pond. Otherwise it should be run out and the land ditched and cultivated. The stream to the north of the pond should be made into a ditch of even descent from its head about 850 feet distant. This would do away with the small pond to the north of the road to the shore, under which there is now an outlet for the water, cut off by the boards which compel the pond to form. It will be necessary also to clear out the bushes. Little can be done with the salt marsh until finally reclaimed. Total cost, $575.00.

A little north of the landing is the Scudder place. An outlay of about $50.00 would remedy troubles here. A pond one quarter-mile west of the house in field could be easily drained. The streams at the entrance gate should be freed so water would not be retarded. The little lily pond lying higher up would make conditions safe if filled up. Both these points would be, in their present condition, easily classed as dangerous even if the entomologists had not so charted them. The same remark applies to pond just inside the road at the Children's Home, part being on their ground and part on Mr. Scudder's. Understanding there is a desire to maintain it, it is suggested that the outlet into bay—again too high—be lowered about three feet, so as freely to admit the salt water, and a gate be put on its inner end so as to automatically let the sea-water enter and hold it within on the falling of the tide. Then fish should be installed. Occasionally this gate should be opened so as to let the water run out quite fully and thus prevent its becoming a brackish pond from its strong springs. The banks of the pond should be kept sharp and clean. Cost estimated to be $270.00. The little pond back of the home, if maintained, can be petrolized at a nominal cost.

SOUTH SEA CLIFF.

The marshes here should be treated the same as at Glen Wood Landing. There is a fresh marsh in the bed of an old fish-hatching pond now run out, but enough water is held behind the partly demolished dam to keep several acres of land wet. Recommendation: Completely open the old dam, ditch the bed of pond and wet area, back the head of stream, and clear out brush. Cost, $275.00.

SEA CLIFF.

Water is confined within road near Pump House. Sink outlet, insert tide-gate, ditch wet lands. Cost, about $80.00. The village itself is in good condition, except as to rain-barrels and the like.

GLEN COVE, ETC.

All the situation which culminates at this inlet forms a perplexing problem. For about four miles the watercourse runs back and southward into the country, sometimes having water for a considerable time in the Spring for nearly its whole length, always holding water for nearly all the lower half the distance. The case divides itself into three parts—the salt marsh, the two unused mill-ponds, and the streams which enter south of the ponds. The salt marsh area of about forty acres has many breeding points, marsh holes, spaces along both of its sides affected by springs, and points left unfilled where some filling has been done. These points could be fully filled or ditched, and graded so as to take off water where now it stands. Springs and streams on Mr. Appleby's land on the north must be opened, and all waters have a free entrance to the bay. The water confined behind dike at starch works should be watched carefully for larvae, as it is likely that breeding occurs here, and it then should be petrolized. The work in connection with this salt area would cost about $300.00. A large scheme to reclaim all of this space inside the bar is practicable, but would involve quite an expense. That could be an after consideration.

The two ponds in the village present the specially difficult feature of the case. As this is quite a commercial center, a commercial treatment is suggested, though an aesthetic one could be adopted nearly as readily as at Roslyn. The treatment may seem heroic, but it is necessary if relief is earnestly

desired and contemplated, and there is no other that can be recommended to be effective.

The mill between the two ponds is being demolished, and it is understood that the water of the lower pond is not used for power purposes by the starch factory, but in the manufacture of their product. This latter use of the water of Glen Brook could be continued by a slight outlay for piping in case the plan here proposed should be carried out. The plan is to run out both of the ponds, and thus obtain a descent all the way from the abandoned ice-pond, east of the railroad, down to the starch factory. The upper dam keeps the water backed up to the road back of General Pearsall's, and faulty grading does not permit a free flow southward of this point for a couple of miles. The areas of the two ponds could be dried out in cold weather and cleansed by storms so as to avoid all unsanitary results of the improvements. It is suggested that a boulevard be run practically along the center line of the ponds, and have a sewer at each side, so as not to necessitate disturbing the roads for sewer connections; that the sewers be arranged to take the water of springs as well as torrential waters from the entire watershed; that owners be required to connect all buildings with these sewers; in fact, that all the drainage of the valley be carried underground from the railroad. This would require some soil filling in the channel of the old ponds; the sides are shallow. An excellent grade of filling material is very convenient on the south side, and could be moved by machinery at a few cents a cubic yard. This boulevard could be intersected by a number of cross streets, which would make a very desirable improvement on account of the limited connections between the north and south sides of this valley. Practically, there is but one connecting road up nearly as far as the depot. These roads would open up important property south of the ponds. Facing the proposed boulevard on both sides would be valuable building sites, backing on others which now face the streets north and south of the ponds.

Such a plan, though involving considerable expense in the beginning, would warrant the carrying a debt for say twenty-five years. The increase in all respects which will come from it would well justify mortgaging the future. No condition, however, would be more advanced than the sani-

tary. No one would venture to claim that these ponds and the connecting streams are in a healthy state with all the foul deposits that are in the beds and margins, the accumulations of many generations. Refuse of dwellings, stables, outhouses, etc., now find way to this great open cesspool. There is not movement enough in the water to prevent breeding of mosquitoes, and they add their quota of danger and discomfort.

Entering the upper lake, a small stream north of the depot comes from as far back as the pond on Nassau Golf Grounds. This pond was referred to in the report of 1900 as dangerous, and one of the entomologists confirmed that opinion in this examination, finding both *Culex* and *Anopheles* breeding. It should be petrolized, or it could easily be drained to the south of the railroad into Gruman's pond, which also should be drained or petrolized, and the waters of this little watershed let run freely down to the lake on an easily obtained grade. They are now held in pools at a number of places, as are also the waters which come down Frost Pond Road. An approximate estimate of the cost of this work, including sewers from the railroad culvert to the factory, and the necessary filling over same for road, opening of cross streets, etc., would be $55,000.00. A part of this amount could be assessed for the improvement at once, which would much overbalance outlay for condemnations. The fees for tapping the sewer would go far towards the interest to be paid on the balance for a long period.

The deserted ice-pond east of the railroad and south of the depot should be emptied and the waters of the valley kept in the present ditch on the west. This pond is a bad breeding place.

The main stream which comes from the south, as well as the torrential watercourse, badly need some grading southward for about two miles. At the north end there is needed considerable cleaning out of brush, which now retards the water, and some ditching to a grade is required. Many of the isolated ponds of this valley, which reaches nearly to Harbor Hill, could be drained into the watercourse from its origin, and thus greatly improve health and other conditions. The approximate cost of this work, from sources to railroad culvert, is $2,400.

In the Dosoris section of the village, about one-third of

a mile southeast of the new public school, is the only natural swamp of any size in all our territory. Here is evidently what is a considerable *lapsus naturæ*—a space without outlet—being an area of about eight or ten acres, and having an entire catchment of about seventy-five acres. Two ponds form at each end—one is used for an ice-pond. The land of the catchment is quite useless as it is, and it is recommended that an outlet tunnel be made to take all the water under the enclosing hill toward the southwest and empty it into the Glen Cove street drainage system. The cost of such a work was not gone into by levelings, etc., but it is thought that this whole difficult situation could be relieved for about $15 an acre.

NORTH COUNTRY CLUB AND RED SPRING COLONY

have a little marsh of their own with a slight stream from the south. The marsh should be diked across its face, a gate set to exclude tides, an open ditch run to gate, lateral ditches connecting, and the fresh stream cleaned and graded. While the marsh is not a very ancient one, it has valuable soil enough when subdued to render the whole area a place of beauty. The pond at the northeast would better be emptied and the water there carried by pipes into the marsh outlet. Approximate cost, if diking materials were near by, $2,700.00.

DOSORIS WEST POND.

As this is but a young marsh, it has not grown over so but that it is simply a mud flat at the lower part of the tides A high-water level could be maintained here, somewhat as at East Island, and improve conditions, or the area could be diked and drained with ditches. For diking and gate the cost would depend on where suitable material for dike could be obtained. If nearby, the cost would be, flooding, about $1,400; for draining, about $550 addition.

DOSORIS POND

in itself offers little danger according to our theories and experience, for the sea enters strongly and prevents large breeding, and the fresh stream entering at the southeast corner does not much affect its salinity. The marsh outside the tide-gate has some marsh holes that should be filled or opened out to the tidal stream. The little fresh water enter-

ing the pond on the middle south requires its courses opened up for free flow. The marsh, however, at the east of the pond has many holes that were breeding *Culex* strongly when visited; in fact, driving alongshore was difficult for man and beast on that account. The stream which enters from the southeast is a very bad feature from its origin a mile southward. It spreads out into ponds natural and artificial at a number of points, all dangerous, and it is recommended that these all be opened out, the course trimmed up, and the stream regularly graded down to the Lattingtown road at a cost of $2,150. From this point northward to Dosoris Pond there is a marshy section, where a road to the shore is contemplated. It is recommended that this road be elevated sufficiently to act as a dike against the waters of Dosoris Pond, which dike, running about straight northward, would redeem and dry the marsh land to the east of it. The water from the south should be kept to the east of the road in a ditch large enough for the entire catchment, and be emptied at low tide into the Sound by an automatic tide-gate. The soil taken from this ditch would go far toward the necessary filling required in making the proposed road. A dike at right angles to the above, where the stream enters the pond, would entirely prevent the pond from overflowing this marsh at its southeastern end.

A culvert under road would be required to empty the inner ditch into the main ditch running northward to the Sound. The cost would be about $2,550.00.

FROST CREEK MARSH

divides itself into three sections—Mr. Guthrie's, Mr. Cravath's, and the one at the east. The dike and sluice-gate at Mr. Guthrie's are drying out his marsh quite effectively, and doubtless when his drainage plans are completed there will be little if any trouble here. At the south end of his meadow area are three ponds that will probably have to be regularly petrolized if they are maintained, and besides should have retaining-walls kept well pointed with cement. Some springs on the east of the marsh, just south of the nursery, form a little stream with pools which were breeding larvae all the season. Cleaning and grading the stream is necessary, or take off the water in tiles and fill in over same. The springy lands west of the meadow and north of the artesian well

form many pools where tree roots have been dug out, which pools were found alive with larvae a number of times this season. These tree-root holes should be filled and the land drained by tiles or open ditch to the main ditch. The wet spaces, which are near the junction of the roads by Mr. Guthrie's west entrance, greatly need drainage into the Guthrie system, as they are bad breeders. The springs from the south of Mr. Guthrie's and the pools by the road must have their courses freed and graded. All the work suggested would cost about $500.00.

At Mr. Cravath's marsh one plan would be to run a dike east and west across its north end, like at Mr. Guthrie's, and in-insert a gate and outlet sufficiently large to take all the water of this catchment without allowing it to overflow the redeemed land, in case of cropping. The dike could be made wide enough on the top to be used for a road, replacing in general the one crossing the low bridge now there. The ditching of this meadow could follow somewhat the course of the tidal stream which now runs in southward to the ice-pond of Mr. Cravath and Mrs. Lewis. As there is a watershed here covering a surface equal to about a square mile, the ditching for torrential water storage must be large enough to hold all without overflowing the meadows while the tide-gate is closed at flood tide. The ice-pond spreads at every heavy rainfall and keeps a large area saturated, and this water is more effectually held in bad pools by the growth of plants, bushes and trees at the sides of it and southward along the watercourses. The conditions here easily account for the many mosquitoes on wing in all this section. The pond and watercourse, which runs southward nearly half a mile, requires to be cleaned of all growths, the bottom of the pond thrown up back of clean banks (or behind a cemented wall), the margins being graded down to the water. North of the pond the outlet requires the same. The marsh would require some lateral ditching besides the ditch inside of and parallel with the dike. The estimated cost of redeeming about twenty-five acres north of the pond is $3,250.00; the pond and southward to source of stream, $675.00. The spring on roadside, south of Mr. Cravath's superintendent's house, which the engineer found breeding *Anopheles* strongly, needs to be cleaned and walled, and its outlet freed to the valley eastward; cost trifling.

The salt marsh entering in the uplands to Firling's ice pond is not large enough to recommend diking it off as the others.

Another plan for the section east of Mr. Guthrie's would be to close the stream about where the present bridge crosses it, and, for the time, let the present creeks act as draining ditches. The construction of dike and tide-gate here would not be difficult, physically speaking. This plan would redeem the whole of the 120 acres lying easterly from the bridge, while the first plan would leave about ninety-five acres unredeemed. The dike could be broad enough to take the place of the Cravath bridge crossing the main creek. Stone enough is near to build the retaining wall.* When the area is dried out, its reduction for cultivation could be effected by leveling off, filling creeks, etc. The first cost of this is estimated at $2,975.00, or about $25.00 an acre.

MILL NECK SECTION,

stated in the Report of 1900 to be the most difficult point in all the area for miles around, involves the consideration of a territory from the Sound to Wheatly Hills—about seven and one-half miles long and an average of about two wide, with two lateral watersheds and streams on the west, one entering the salt marsh through Kaintuck Pond, near the railroad, and coming from about a mile southward of the old canning factory, which is west of Locust Valley station, the other through Remsen's Pond, from near the junction of the stone road, between Buckram and Bayville, and Feek's Lane. There are no considerable difficulties on the east side of Mill Neck marsh, the principal one being the pond, which is formed of springs, just south of the house (new owners) on the west side of the road that skirts the marsh. These springs keep a large area wet, and should be confined to sharp banks and run off to the channel by tile or clean open drains. Larvae were abundant here this season. The cost of work here and northward would be about $300.00.

We will consider first the side issues on the west, then the end of the marsh south from the railroad, taking in the very dangerous situations about Francis Pond, and follow still southward up through Woolvers' Hollow, Brookville, and so on to the most remote sources of Mill Neck troubles,

* See Appendix I. with Sketch.

viz.: the pond on ground of Mr. E. D. Morgan, near the crown of Wheatly Hills, and the many others thereabouts. We will then consider the marsh area proper.

Remsen's Pond (three owners) is caused by the damming up of spring and surface water of a watershed of about 400 acres. The shore road crosses the dam, and so again the dam has its use to that extent and that extent only. The old mill is gone, and the pond, with its bad marginal conditions, are only useful as breeding places. The small stream, from springs westward, runs through a tangled mass, especially north of the stream, and pools are frequent. It is recommended that this jungle be trimmed out, the springs and streams opened up, the course straightened, the pond emptied entirely, and the outlet below the dam opened and graded down to new ditching system for the marsh. If the water is needed for stock, it could be taken as well from a narrow channel, allowing most of the present alluvial bed to be cultivated by its owners, making a picturesque spot of what is now quite the reverse. If needed for ice, a pond could be formed by closing the gate at the end of the breeding season. The total cost would be about $1,650.00.

Kaintuck Pond (Mr. Ingraham, owner), seen by the north side of the railroad, is maintained by a dam where also was a mill which has entirely disappeared. Its occupation, like the others, is gone, and with that its usefulness. The area under it would lend itself well to a beautifying scheme for this section. The road over the dam could be maintained, as well as a gate and sluice under it, for use as heretofore explained.

The area below the dam is springy and swampy, and is, as well, affected by the tides. About seven and one-half acres would be made valuable land by keeping out tides, provided it was cleaned up and ditched. To carry out a reclamation from the tide marsh back to the railroad culvert would cost $875.00.

At the west end of Kaintuck Pond this watercourse passes under the railroad and, in a generally westerly direction, is active back to a point west of Buckram. Following up the stream from the culvert, we find the site of another old mill, the dam has been washed away and the mill-pond does not exist. The old bed, however, is a cat-tail swamp which needs to be ditched and cleaned up.

The springy land on the hillside south also requires draining to channel. The stream is quite active here and westward. The stream divides and receives a strong accession from the springs which saturate a large tract of land south of the railroad west of the stone road, which here runs under the railroad. The land in this corner badly needs drainage with open ditches or tile and the section cleaned up.

There is descent enough to prevent the pools in Buckram, where the north branch of the stream intermits along the roadside. Houses are built over the watercourse and pools are frequent, and larvae are abundant, with the unhealthy consequences. A large pool in the bushes west, at a sharp turn in the road and between it and the railroad, requires to be drained out into the channel, which needs some grading back to where a branch from the stone road and the watercourse go under the railroad. Through this part of the village of Locust Valley the watercourse is in fair condition, but when it gets toward the canning factory there is a dam built across the little valley, completely blocking up the stream, and backing it up for a distance of a couple of hundred feet. This dam should be removed and the water which comes from a mile south be allowed free course down to Kaintuck Pond, two miles away. The cost of grading, ditching, draining and cleaning from source to pond is estimated to be about $1,350.00.

We now come back and take up the Mill Neck section itself, from the railroad southward. The cultivable soil of marsh just south of the railroad is shallow, but there is depth enough to make a very valuable tract of land back to the dam of the lower pond. As it is, covered with bushes and trees, with a tortuous fresh stream through it, which has many tributaries from springs along the uplands, and the area at times affected by the tides, it is a perfect breeder in appearance and in fact. It requires a gate at the railroad culvert to keep out tides, its stream straightened, its growths trimmed out, the adjoining streams carried by sharp banked ditches direct to the main stream—the cost of all which would be about $6,050.00, redeeming about seventy-eight acres now of normal value and as a breeder worse than valueless.

FRANCIS POND AND LOWER POND,

with the marsh above, cover an area of about thirty acres and form no serviceable use. The section all about them and below them is probably the worst part of our territory for mosquitoes. No relief can be expected for a large area around until conditions are radically changed. It is recommended that the two ponds be let out and the marsh west of the Oyster Bay road be drained by running the culvert under the road two feet lower, and the growths all removed. A ditch should be made the entire length of 4,300 feet to carry the water all out of the dam at one place. The sum of about $1,000, or about $30 an acre, will do all this. In case the old channel of the lakes would answer for a drain with but little labor, probably $20 an acre would be sufficient. This would cover all the side issues here except those given separately in the indexed report, the principal one being the stream coming down from the west, starting on land of J. J. Weeks.

The stream which comes down from the south is active for 2,500 feet, and then is intermittent. The watercourse, as before stated, follows up Woolvers' Hollow, Brookville, etc., to Wheatly Hills. At times a heavy stream flows down this valley, generally on the roadsides, often in the fields, and this torrential supply leaves pools along up the valley which remain long enough to supply several broods of mosquitoes. A few springs and ponds furnish their quota, and the valley has its troublesome results, which might be easily avoided by grading the roadsides for its length. There is a descent from 265 feet over mean sea level at the southern pond examined (Mr. Morgan's) to 127 feet at Brookville, thence to 80 feet elevation where the stream becomes active, so that grading could be made very effective in taking off the surface and pool water. The cost of the work along these four miles would be irregular, but with bridges and all would be about $1,200.00.

MILL NECK MARSH PROPER

extends from the railroad to the road along the Long Island Sound side. Having disposed of all the sources which supply it with fresh water, we consider the marsh itself. It may be divided into its upper and lower halves, the outlet being about midway of its length. A study of it shows that the whole area between the surrounding uplands is gradually

being filled with the marsh formation, much of it, especially those parts in the indents, being completed marsh, while along the edge of this it has only reached the mud-flats stage. These mud flats will increase in area yearly by the deposits from sea and land, and finally, as in the case of Huntington Harbor, occupy nearly the whole area at low tide. In a few generations more it will be solid marsh within a line between Mill Neck and Oak Neck, except in the course of the tidal stream. If this space, with its valuable deposit of soil, were in Holland or in North Germany or in some sections of England, it would be under cultivation in a brief time. By a double roadway dike 1,485 feet long across the outlet, or about 1,250 feet long at the narrowest point, this entire area of 395 acres would be easily recovered from the sea at a cost of $27,900.00, or $70.00 per acre. This is the plan the writer referred to, without details, in his report of October, 1900, as the surest remedy for all the troubles from this marsh and its borders.

An alternate plan would be to dike off the north and south ends of the marsh as near to the outlet as possible. At the north end the whole of that section could be recovered by a single roadway dike 1,162 feet long and an automatic gate under. This would reclaim about 140 acres and cost $4,550.00, or about $33.00 per acre, and open up a short cut to the south end of Oak Neck. At the south end of Mill Neck marsh a dike 1,155 feet long run across north of old tide mill would redeem about eighty acres, at a cost of $8,900.00, or $110.00 per acre. If this dike should be run across the narrow place just south of the boatyard, the cost would be reduced and the area redeemed increased, or by utilizing the present causeway as far as practicable the cost would again be reduced, but the area would also be reduced. These figures are based upon obtaining diking material at least expense.

A recapitulation would show that the whole marsh, of about 400 acres area could be redeemed for about $70.00 per acre, or about 220 acres of it for about $60.00, which would leave about 180 acres unredeemed, valueless, a constant menace, especially along its shore, and always an unsightly feature, and increasingly so with the encroachment of the mud-flat area.

CENTER ISLAND, ETC.

The marshes east of the new iron bridge might require some opening out of pools, or in some instances filling at a cost of about $250.00, though examinations show no larvae at such times.

The Center Island Committee have a report on what work is needed to finish plans there, and the cost of same.

OYSTER BAY.

Beekman Pond source and outlet appears to be under treatment by owner—certainly the outlet is—and probably under an engineer's supervision. The pond, like all the other water surfaces formed by the hand of man, presents its difficulties. The better way would be to drain it all off and let nature have her way of caring for the water which comes down from springs above. If this is not done the sources and entering watercourse would have to be cleaned of growths and graded. The pond banks should be made sharp by a cemented wall and graded so as to hold no water. The pond itself would have to be petrolized in the breeding season or run off from Spring to Fall. The suggestion for using it for ice, given elsewhere, would apply. An estimate of the cost of cleaning and grading the entering watercourse would be $250.00.

OYSTER BAY PROPER.

There are two natural fresh water streams through this village, one by the way of the mill-pond and one comes out into Sammis Creek. The latter has its dangerous features, for the reason it is quite largely concealed under houses, etc. It starts south of the post-office three and half blocks, about on a line of the new public school, in a springy piece of land about 400 feet east of South Street. There is ample difference in height between the source and outlet to give a safe grade to this stream, but as it is it is choked up for want of grading, and is practically stagnant in many places, which form dangerous conditions. This stream should be cleared and graded, and, being in the midst of the village, the bed and sides should be paved, or, better, a sewer should be built large enough to take the torrential water of this valley and the refuse water from the dwellings, etc. Breeding of *Anopheles* takes place in most of the course.

The cost of grading and a simple open drain would be about $600.00. In the end the most thorough work would be the most satisfactory in every way, especially in sanitary results.

The mill-pond and its entering stream, together with the mill-race, form the largest danger in Oyster Bay. The water-course through Poverty Hollow from the south is about three and a half miles long. Starting at the crown of the watershed, about a mile and an eighth south of East Norwich, with an elevation there of about 225 feet and 190 feet at East Norwich, it passes northward, but at times is almost level, hence is choked up and spread out in wide wet areas, which would all be overcome by grading the descent. The bad ponds in East Norwich referred to in the indexed report, which empty into this valley, could easily, and most certainly should, be drained. From them northward the water-course is first on one side of the road and then on the other, necessitating the maintenance of bridges, and causing the course to become level in some points for long distances, with resultant pools. It is recommended that a steady grade be effected, the neighboring pools and ponds emptied into the channel, and all water brought down to where it passes under the stone road, costing about $1,250.00.

From the stone road northward very troublesome conditions prevail. The growth of bushes and the frequency of springs cause wide wet spaces in some places. Some points are even dammed up to restrain the free flow. The bad results of all this are graphically seen on the map. A wide main ditch should be run to the mill-pond, with lateral ditches on either side; the bushes and trees should be cleaned off almost the entire area, here surrounded by the roads, all at a cost of about $3,100.00. The troubles resulting from the mill-pond itself would best be relieved by letting it entirely out, as has been recommended for others, thus yielding a beautiful, fertile field for cultivation, or, by fuller drainage, affording valuable building sites. The cost of drainage of pond area for agricultural purposes would be nominal—probably $500.00 covering all, and this would render more easy and effective the drainage way southward to the stone road. This would, of course, do away with the very bad long mill-race. If it is not drained it should have its sides built up with stone, with cement joints, and the soil from shallow

water thrown back behind them to a grade, and the same done to the race. This would cost about $4,100.00. The pond would probably still have to be petrolized in breeding season.

The marshes between the dam and the railroad should be ditched and cleaned up, and a tide-gate be put up at the culvert, when all of this area would be drained for cultivation for about $410.00. If used for certain class of buildings, the stream banks should be diked at an extra cost of about $1,500.00. Just on the east of the mill-pond, and below its level, is a wet area that finds its outlet through a stream that runs between two houses to the side of the main road, crosses under it, thence down Larrabee Street to the bay. The whole condition of this stream from source to tide-water is bad, and should be cleaned up and graded. A tile sewer-pipe of about 12-inch diameter, with openings, would be the safest remedy, but the cost of open drainage would be about $150.00.

Maxwell Street ditch and an old cistern there account for some of the trouble of this section.

The ponds inside the railroad track and north of West Main Street—mostly from the overflow of an artesian well—should have sharp banks, as heretofore recommended, and be stocked with suitable fish. They could be made safe for about $75.00.

Some springy land west of Mr. Weekes' property, on the south side of East Main Street, needs drainage very badly. Cost about $25.00. The ponds on the north side of this street require to be drained out, or tight banks made to them all and petrolized or stocked with fish.

That leaves to be considered the marsh land outside of the railroad embankment, in all fifty-two acres. This becomes an instance referred to where the cost of reclamation is disproportionate to extent. A strip of land from the mill on the west to the east side of the village is gradually being enlarged by the marsh encroaching on the sea, a fact made possible by the quieter waters in the bay. The length of this strip is about 6,600 feet, and a dike of that length, strong enough to resist the force of the waves in the bay, would cost $15,100.00, or about $300.00 per acre redeemed—probably a prohibitive price. And yet even this cost would be justified where the land reclaimed is facing a growing village and

where utility and beauty would have much force in an argument for the undertaking.

If such a dike is not built to exclude all tidal waters, it will be necessary, simply for the purposes we desire to accomplish, at least to expend a considerable sum in ditching for outlets as well as in letting out or filling of marsh pools, etc., say $1,900.00.

HEAD OF OYSTER BAY COVE.

Though a valley comes in at this point, there is not much water to care for except torrential. Yet the valley has its troubles of mosquitoes, which may be obviated by a small expense compared with some of the other entering valleys. There is no mill-pond to contend with, and the length of active water is only about one and one-quarter miles, with heavy grade beyond. The channel is east of the center of the valley, but the entering streams, causing many saturated areas, are almost entirely from the west, so that there are many long lateral drains to be made. The cost of them and of draining the ponds are all in the indexed report of cost, etc. The principal trouble of this nature is from Fleet's old mill-pond, back of where Mr. Huntington now lives. The descent that can be obtained in the valley is not great, but enough to dry it out as well as the ponds. It is recommended that the channel be widened, its banks cleared of bushes, etc., and an even grade be obtained at a cost of $1,850.00.

COVE NECK.

Along the head of the cove and on the west side of Cove Neck to the point are some narrow marshes that could be reclaimed, but the acreage would hardly warrant. It must be done principally, if done at all, as a beautifying scheme. Meantime, to let out the water of the marsh holes or fill them would be the remedy, or to petrolize them if much isolated. Either of the former two ways would cost, north to the point, about $500.00. At the point is a marsh which could be easily redeemed by closing the creek at its mouth with a tidal gate and raising a dike around it, and ditching within, at a cost of about $2,050.00.

On the east side of Cove Neck we have Eel Creek marsh, which is a comparatively young one, and hence has but a

shallow cultivable soil, and yet enough to warrant its redemption. The bar has been formed starting at the north, opposite an inward curve in the shore line, and has worked southward, so that it is now about 1,600 feet long and nearly high enough to keep out tides. Planting more beach grass (*Ammophila Araneria*) along the bar would soon elevate it (by intercepting the sand) high enough to act as a complete dike. Or the bar might be at once heightened by land and beach grass planted in the face of the dike, as is sometimes done. Then the creek should be shut out and a tide-gate inserted. There is no interior water to speak of, except surface water from a quite large valley entering the uplands. About eight acres would then be recovered from the sea at a cost of about $1,950.

COLD SPRING HARBOR.

At the west side—Bungtown—there is needed near the Laboratory some drainage, preferably mostly by porous tile, of the water that comes out of the hillside both above and below the road, and the carrying of same down to the bay, at a cost of about $400.00. If tile is used for all the work, probably $100.00 more would be needed. At the State Fish Hatchery it is recommended that all the sides of pools be made of stone laid in cement; that the pond behind the main building have its east wall and bank made water tight, and the piping be tightened so as to avoid the wet space so near (and probably extending under) the Superintendent's residence. The entomologists report that this pond was not stocked, and that *Anopheles* larvae were found in it, with usual results. The pond on the hill about 800 feet west, belonging to Dr. Jones, and whose waters are carried to the hatchery, was reported in October, 1900, as a dangerous place. This year's inquiries show that *Anopheles* here abound. As before recommended, the pond waters should be gathered by throwing up the bottom soil, preferably behind stone and cement banks, cutting out all brush and freeing the outlet through which the surplus water is carried under the road and along down hill to the bay. This would cost about $300.00. Another plan should be mentioned of taking all of the water from these springs down to the Hatchery direct in pipes from the springs, doing away with the pond entirely, as well as the troublesome watercourse

down the roadside. It was on this road, at its junction with the Laurelton road, that the old mill and dam stood, supplied from the pond we are now considering. If the pond was done away with according to the last suggestion, there would be left a fertile little garden spot in its bed.

The treatment for St. John's and the other two lakes is difficult to suggest. While two of the three old mills are gone the small population about them would hardly warrant their obliteration, though *Anopheles* were found. The least that can be recommended is to clear the banks of all of their growths and make them sharp so as to harbor no larvae. At places in the beds of the lakes where shoaled the soil would have to be thrown back on the banks. The water of the middle lake held back of the old railroad embankment should, as recommended a year ago, be let out into the lake. It becomes so stagnant that it is one of the most prolific breeding places in all the sixty square miles of land area. Its brood would fill the section north to the village and easily account for the mosquitoes that tradition claims come all the way from the south side of the island. It is recommended that this embankment be cut down at its middle and the soil used to fill in the ends of the pond; and enough soil be used to make a descent from each end out through the embankment to the lake. This work on the lake is estimated to cost $1,500.00 to $2,000.00.

The roadside up to the Cold Spring depot holds water in pools coming from springs and from rainfalls. This should be carried to the ponds by a cleared and graded ditch, at a cost of about $100.00.

The mill-race in use needs its banks cleared and made sharp, or better, a stone and cement wall built. Petrolizing would be useless. Clearing would cost about $100.00.

It is recommended for the marsh area that it be diked off about at the Laboratory with a tide-gate, and ditches large enough to take the strong flow of water from the southward. To recover about thirteen acres would cost about $3,550.00.

The marsh near and opposite the village is not considered a menace, nor is it large enough to recommend its reclamation.

The pond of Mr. De Forest would better be drained off, but in the absence of that its banks should be protected, as

recommended elsewhere, and the pond petrolized or successfully stocked with fish. To properly wall its sides and clear up its sources and connect drainage would cost about $550.00.

The inner part of shore roadside northward, as recommended in 1900, should be drained under the road or preferably filled, at a cost of about $75.00.

The marsh on west shore, south of Lloyd Harbor, would be disposed of in the treatment of the harbor itself. The writer reported some months ago that, in his opinion, if the bar was opened at its narrowest point the tidal current in the straits thus made would scour a navigable channel. The marsh in the harbor is comparatively young, as shown by the fact thas it has mostly only reached the mud-flat stage. The opening of the bar would be a matter costing about $500.00, but that action would necessitate a bridge, at a large range of cost on which no estimate is made.

Another plan for the Lloyd Horbor flats would be to dike off the water as far east as desirable and reclaim the land within, which the Government Report of Mr. Thomas H. Means, soil specialist, shows to be valuable in fertility.

The large shore ice-pond of Yates' estate, just north of Mr. Matheson's, was examined during the winter a year ago and previously. A test was made, standing on the ice, and the whole bed was found to be filled in many feet with alluvion. A report was then made which it is not necessary here to repeat.

The marsh at Lloyd's Point and the large shore pond about one and one-half miles east of it are not reported upon.

COST.

The estimates made herein do not include the cost of administration, nor the cost of any work to be done on Center Island or Lloyd's Neck.

Total approximate cost of work is $141,000.00, as above itemized, of which about one-half is for the two suggested improvements at Roslyn and Glen Cove.

Total approximate cost of filling or draining ponds, as mentioned in Indexed Report, $876.00. This work should be done mostly by individual owners, without cash outlay.

Total approximate cost of fuel oil until drainage of such ponds as can be drained is effected, $420.00.

If the recommendations as to drainage of ponds, etc., are carried out, this latter amount would be reduced to about one-third of that amount.

The cost for oil required for other points than ponds and the like—for instance, large lakes, marsh pools, streams, cisterns, etc.—is uncertain, but would approximate $750.00, and would be reduced probably to a tenth of that when the larger drainage plan is carried out and the domestic sources obliterated.

[Signed] HENRY CLAY WEEKS.

Bayside, L. I., N. Y. City,
December, 1901.

Indexed Report (with References to Map) of Henry Clay Weeks, Engineer in Charge.

The following tabulation will facilitate finding the treatment recommended by the engineer for all water surfaces. Where it is one that can be disposed of in a line, the description, treatment, etc., will all be found hereunder in abbreviations as explained. Where it is a larger or more difficult point there is a reference to the special reports on such places, given in consecutive order in the Detailed Report of engineer, beginning on the west and following along the shore line. It is well also to refer to the general report in which the methods of treatment, etc., are more fully explained. Exact locations are of necessity not attempted to be shown on the map. The numbering on map is arranged so that districts east, west and south of the present one may be mapped to join as a continuation. The sides of each small section of the map represents one-third of a mile in length.

EXPLANATIONS.

The figures at the left of the tables under the letters "H" and "V" are the numbers on map margins, those coming first being the horizontal references, and those second the vertical.

The figures in the descriptions refer to sizes. As "250" would mean that the area of the water surface is equal to a square of that number of feet.

"C" means clean out, "D" means drain, "F" means fill, "P" means petrolize, "S" means stock with fish.

The figures on the extreme right indicate the approximate number of days that the work recommended would take.

H.	V.		Area.	Treatment.
48	94	Lloyd Point Marsh		No report.
49	94	Pond.		
49	95	Pool in stable yard. Yates Estate	20	P
49	99	Shore pond on Lloyd Neck		No report.

H.	V.		Area.	Treatment.
50	93	Pond and stream of Lloyd Point Marsh		No report.
50	99	Shore pond and stream entering. Dr. Derby.		No report.
52	93	Shore Pond ; ice-pond. Yates estate.		Former special report.
52	101	Shore Marsh. Lloyd Harbor		Special.
53	97	Pond of O. E. Schmidt	25	P
53	99	Ponds of Dr. Derby	40	D 1
53	100	Springs and streams at Dr. Derby's tenant house		C & D 8
53	100	Shore Marsh, Lloyd Harbor		Special.
54	88	Marsh. D. L. Dresser	Center Island	Special.
54	88	Shore Pond	"	"
54	88	Spring, streams and marsh. C W. Wetmore	"	"
54	89	East shore ponds. C. W. Wetmore	"	"
54	89	Three ponds. C. Hoyt	"	"
54	97	Lloyd Harbor Tidal Flats		Special.
55	78	Frost Creek Marsh, northeast		"
55	79	Mill Neck Marsh, north		"
55	84	Two pools at roadside	75	F
55	89	Inner Great Meadow	Center Island	Special.
55	90	Outer " "	"	"
55	90	Pond. Mr. Shaw	"	"
55	95	Salt Marsh		Special.
56	75	Frost Creek Marsh, P. D. Cravath		"
56	76	Frost Creek Marsh, P. D. Cravath		"
56	77	Frost Creek Marsh, P. D. Cravath		"
56	78	Frost Creek Marsh, P. D. Cravath		"
56	79	Mill Neck Marsh, north end		"
56	80	" "		"
56	81	" "		"
56	81	Mr. Talbot		D

H.	V.		Area.	Treatment.
56	88	Shore pond. Mr. Sherman, Jr.	Center Island	Special.
56	89	South end of Inner Great Meadow	"	"
56	90	Brackish pond. Mr. Shaw	"	"
56	91	Two brackish ponds. Mr. Shaw	"	"
57	71	Duck pond and stream. L. Jacobs	75	C & S or D 3
57	72	Dosoris Pond. L. Jacobs		Special.
57	73	Dosoris Pond, brackish, east end		"
57	73	Dosoris Pond, marsh, east end		"
57	75	Marsh and streams. W. D. Guthrie		"
57	75	Streams from wells. C. O. Gates		D
57	76	Frost Creek Marsh. W. D. Guthrie and P. D. Cravath		Special.
57	78	Ice-ponds and streams entering. Firling	200	D 1
57	79	Pool back of barn. Peter Cox.		
57	80	Mill Neck Swamp and outlet of Remsen's Pond		Special.
57	81	Mill Neck Swamp		"
57	83			
57	96	Ponds at brick yards	300	Por D 15
57	98	Pond with island	100	Por D 5
58	70	Roadside pools		D 3
58	71	Dosoris Pond		Special.
58	72	Dosoris Pond and stream from south		"
58	73	Dosoris Pond, marsh and stream, from south		"
58	74	Springy land, 3 ponds of S. Hall and Mr. Frost	65	D 10
58	75	Marsh and stream. W. D. Guthrie		Special.
58	77	Ice-pond. Mrs. Lewis and P. D. Cravath		"
58	77	Marsh and stream. Mrs. Lewis and P. D. Cravath		"
58	77	Marsh and stream. P. D. Cravath		"
58	79	Pools. P. Cox		F or P
58	80	Mill Neck marsh		Special.
58	80	Old Mill Pond, stream in and out, fresh and salt marsh		"
58	81	Mill Neck marsh		"
58	82			

H.	V.		Area.	Treatment.
58	88	Shore pond. Mr. Smith	Center Island	Special.
58	91	Shore marsh		Special.
58	92	Pond, Frank Swan		Filled.
59	69	Wet lands, Pratt Estate		D 2
59	70	Tidal flats and stream. Pratt Estate		Special.
59	70	Water course. Pratt Estate		D 10
59	73	Pond, stream and wet lands below pond. Pratt Estate		Special.
59	74	Springy land and stream		D 10
59	75	Three ponds and three streams entering W. D. Guthrie's meadow from south		Special.
59	77	Spring, wet land and pond. P. D. Cravath	30	F & D
59	79	Springs, fresh marsh and streams to Remsen's pond		Special.
59	81	Mill Neck Marsh at causeway		"
59	82	Wet lands, Mrs. Lena Cox		D 10
59	84	Partly drained marsh. R. Townsend		D
59	87	Brickyard ponds. C. W. Wetmore	Center Island	Special.
59	87	Small salt marsh. Mr. Smith.	"	"
59	88	Springs and stream dammed up C. D. Smith	"	"
59	89	Shore pond. Mr. Smith	"	"
59	92	Pond of Mr. Smith and pond and wet land of T. Roosevelt	60	D 10
60	69	Pond and stream		Special.
60	72	Sink hole		Filling.
60	73	Pond and stream. Pratt Estate		Special.
60	74	Stream. "		"
60	75	Water course entering meadow. W. D. Guthrie		"
60	77	Spring and stream. P. D. Cravath		C & D
60	81	Mill Neck Marsh, Kaintuck Pond and stream. Mr. Ingraham		Special.
60	82	Mill Neck Marsh, spring and pond at each side		"
60	84			
60	85	Stream from Beekman Pond		"

H.	V.		Area.	Treatment.
60	92	Pond. T. Roosevelt	50	D 5
60	94	Eel Creek Marsh. T. Roosevelt and others.		Special.
60	98	Pond in deer yard of Walter Jennings..	15	Por F 5
61	69	Marsh and stream		Special.
61	74	Stream and wet land		"
61	78	Stream and pond Buckram roadside		"
61	79	Stream Buckram roadside		"
61	80	Fresh marsh and stream entering Kaintuck Pond		"
61	81	Mill Neck Creek and wooded marsh		"
61	82	Mill Neck Creek and wooded marsh		"
61	84	Watercourse entering, and Beekman Pond..		"
61	85	Mill-race		"
61	86	Oyster Bay, marsh and streams		"
61	87	" " "		"
61	91	Shore marsh		"
61	98	Pond, James and De Forrest	50	Por F 10
61	100	Pond, Mrs. Dennison	20	D 1
62	68	Pond	40	D 5
62	68	Streams and wet sands		D 8
62	77	Watercourse through Locust Valley		Special.
62	79	Stream to Kaintuck Pond		"
62	80	" " "		"
62	81	Lower Francis Pond, stream, wet land east and wooded marsh		"
62	85	Mill-race		"
62	86	Mill-pond, race and stream		"
62	86	Two ponds south of meadow		C and S
62	86	Road stream from mill-pond, east		Special.
62	87	Stream entering Sammis Creek		"
62	88	Shore marsh and stream entering Sammis Creek		"
62	89	Shore marsh		"
62	89	Three ponds. F. G. Underhill		Por S
62	91	Shore marsh		Special.
62	92	Streams and pond. W. J. Youngs	200	Watch.
62	94	Ponds at Laurelton Hotel		Por D 3
62	98	Mr. De Forest's lake		Special.

H.	V.		Area.	Treatment.
62	99	Stream and wet lands above Mr. De Forest's lake		Special.
62	100	Two ponds. I. W. Valentine	75	D 1
63	68	Shore pond.		
63	72	Pond and fresh marsh. Townsend Titus		Special.
63	72	Ice-pond and fresh marsh. Frank Coles		"
63	72	Swamp		"
63	76	Ponds, etc., behind canning factory. S. Underhill and Fitzhugh Smith		"
63	80	Pond and wet lands. J. J. Weeks		D 15
63	81	Stream from pond of J. J. Weeks, also marsh and pools at Francis Pond		D 15
63	81	Upper Francis Pond and marsh below		Special.
63	86	Wet lands and stream entering Oyster Bay mill-pond		"
63	87	Springs and stream east of South Street, Oyster Bay		"
63	91	Spring and stream		D 10
63	92	" "		D 10
63	94	Pond at Laurelton Hotel		Por D 2
63	96	Ponds of Wood and Chapin		Por D 5
63	98	Marsh at Cold Spring Village		Special.
64	57	Marsh at Prospect Point		"
64	58	" " " "		"
64	59	" " " "		"
64	68	Pond Mr. Appleby		"
64	70	Springs and wet lands Mr. Appleby		"
64	71	Glen Cove lower pond. Starch factory		"
64	72	Glen Cove upper pond		"
64	73	Stream entering Glen Cove upper pond		"
64	74	Pond of Leonard Cole	30	P
64	74	Pond in Golf Links	50	D 3
64	74	Pond and outlet. Mr. Gruman		Special.
64	76	Small pool. B. W. Craft	20	Por D 10
64	76	Pond. Senator W. W. Cox	50	Por D 4
64	81	Pool on roadside	20	Por D 15
64	81	Stream, wet lands, and pond above Francis Pond		Special.

H.	V.		Area.	Treatment.
64	85	Stream and pond. D. C. Silleck.	20	Special.
64	92	Stream in and out, and Fleet mill pond.	150	C & D 10 or C & P
64	93	Stream to Cove...		Special.
65	69	Springs and marsh. Mr. Appleby.....		D
65	69	Pools. Mr. Appleby.....		Special.
65	70	Springs and streams. Mr. Appleby.....		"
65	70	Springy land at head of Mosquito Cove.....		"
65	70	Marsh pools.....		"
65	73	Glen Cove upper pond, and streams entering		"
65	73	Pond of Gen. J. B. Pearsall.....	10	D or F 1
65	73	Glen Brook and old ice-pond of Frank Coles.		Special.
65	75	Ice-ponds of W. H. Willets and F. K. Willets	125	D 5
65	75	Pond of Mr. Willets.....	50	P
65	80	Stream and watercourse to Francis Pond...		Special.
65	83	Pond on Mr. Sammis farm.....	25	P
65	85	Watercourse		Special.
65	89	Three ponds. C. Weidenfeld...	75	D 2
65	91	Pond of T. Bailey.....	30	P
65	93	Stream in valley to Cove.....		Special.
65	93	Pond. Samuel Fleet.....	40	D 5
65	97	Pond, springs, and stream of Mr. De Forest...		D 15
65	98	Mill-race.....		Special.
65	100	Ponds. David Jones.		
66	69	Mosquito Cove, marsh pools.....		Special
66	73	Glen Brook.....		"
66	75	Frost pond. Estate of E. Coles.....	200	P
66	78	Pond. Remsen Youngs.....	30	P
66	80	Springs, pools and ice-pond. Jas. R. Cock.	75	C and D 2
66	84	Springs and watercourse.....		Special.
66	89	Two ponds in golf grounds.....	75	P
66	90	" " " " Moyses Bros.	75	D by gate 10
66	93	Pond, $\frac{2}{3}$ Mrs. Blanchard, $\frac{1}{3}$ Estate of Mrs. S. Jones.....	300	D 30
66	97	Springs and pools at Laboratory.....		Special.
66	97	Pond of Geo. E. Brightson.....	25	D 7 or F 20

H.	V.		Area.	Treatment.
66	98	Marsh and pools		Special.
66	98	State hatchery ponds		"
66	103	Pond of Mr. Cassier	50	D 2
67	73	Glen Brook		Special.
67	77	Pond. Remsen Youngs	25	P
67	78	Pond. John Mennin	10	P
67	81	Pond. G. Van Cott	35	P
67	84	Watercourse and pool of Geo. Ramlose	15	D
67	85	Watercourse and pool of A. J. Vernon	12	D
67	86			
67	90	Three ponds of Suydam Estate	50	P
67	91	Pond of Suydam Estate	115	D 5
67	92	Pond of " "	25	D 2
67	95	Pond and stream near school house. Dr. Jones	70	Special.
67	97	Pond on Moore Estate	25	D 1
67	98	St. John's Lake		Special.
68	72	Pond. Mr. Craft		D or P
68	74	Watercourse of Glen Brook		Special.
69	80	Watercourse on roadside		"
68	85	Watercourse		"
68	87	Pond. Charles Dehn	25	D 1
68	88	Pond. Mr. Boice	60	P
68	90	Wet lands	50	F
68	91	Pond. P. Callan	100	P
68	97	Pond. Jos. S. Doty	150	Por D 10
68	97	Pond. Mr. Doughty and S. Jones, deceased.	100	P or D 2
68	97	Pond. Dr. O. L. Jones	100	P or D 5
68	97	Pond. J. H. Doughty	125	P or D 10
68	99	Middle Lake and confined water at side. Dr. Jones	55	Special.
69	68	Marshy land and pools near pumping station.		Special.
69	74	Upper Glen Brook		"
99	74	Pond of Mr. Watt	35	D 3
69	80	Watercourse on roadside and pond of Charles Devine	25	C and P or D

H.	V.		Area.	Treatment.
69	86	Pond of V. Martling	20	F or D 2
69	86	Ponds of Hy. Vernon and Charles Bailey	200	D 10
69	89	Pond of	50	P
69	99	Swamp and stream entering Middle Lake		Special.
70	68	Salt marsh		"
70	68	Pond and stream of Mr. Isaacs		"
70	69	Pond. ½ Children's Home, ½ T. Scudder.		"
70	73	Two ponds. Mrs. Downing	100	D 5
70	73	Watercourse of Glen Brook		Special.
70	81	Roadside stream, springy lands and pond of E. E. Price		C and D 15
70	86	Island Pond. Richard Downing	300	D 15
70	86	Two ponds	50	P
70	87	Three ponds. Martling Bros	125	P
70	93	Pond. Samuel Titus	150	F or P
70	98	Stream and Pond. Dr. Jones	100	C or D 10
70	100	Marsh above upper lake		Special.
70	101	Pond and vats of Dowden's tannery	30	C 5
71	67	Ponds. Mr. Thayer	175	D or P
71	69	Two ponds and stream at roadside. T. Scudder		Special.
71	69	Field pond. T. Scudder		"
71	69	Sources of Glenwood Creek		"
71	69	Ice-pond and stream. G. H. Townsend		"
71	70	Sources of Glenwood Creek		Special.
71	73	Watercourse Glen Brook		"
71	73	Wet lands and two ponds of F. McCoon	40	D 7
71	76	Spring in woods. T. F. Bailey		D 2
71	76	Pools. "		F
71	76	Pond. "	35	D
71	77	Pond. J. H. Youngs	50	P
71	78	Pond. Frank Nostrand	75	P
71	81	Spring and wet lands of Mich. Conway roadside stream		C & D 20
71	94	Pond. A. Cheshire and three others	400	P
71	99	Stream from Dr. Jones' pond		C & D 5
71	100	Roadside stream and wet lands from Dowden's tannery, ponds of S. W. Montfort	75	C & D 8

H.	V.		Area.	Treatment.
71	100	Railroad reservoir and outlet	25	C 3
71	100	Marsh lands and stream from Dowden's tannery		C & D 15
71	101	Pond. Brush Estate	75	D 5
72	70	Mill-pond stream. Mr. Willets		Special.
72	70	Mill-pond. T. Clapham, springs and outlet		"
72	72	Pond. W. H. Simonson	40	D 2
72	73	Torrential Glen Brook		Special.
72	74	Two ponds. G. H. Townsend	130	D 8
72	74	Torrential Glen Brook		Special.
72	74	Pond. Horace Duryea	40	D 3
72	77	Ponds. Thos. Underhill	20	D 2
72	81	Pond. D. T. Luyster	30	D 2
72	85	Pond. Geo. Underhill	150	P
72	85	Pond. Jos. Layton	35	P
72	85	Pond. Mrs. Duryea	20	P
73	69	Marsh at Glenwood near Ayres' Hotel		Special.
73	70	Wet lands and stream. T. Clapham		"
73	74	Torrential Glen Brook		"
74	68	Springy shores		D 10
74	69	Pond. Gen. A. Ward	125	P or S
74	69	Springs and pond.		
74	70	Ponds and stream entering. R. A. Ryley		Special.
74	74	Torrential Glen Brook		"
74	80	Pond. J. Hartigan	25	P
74	82	Pond. Sherman Hauser	75	P
74	83	Pond. Shirley Tappan	40	P
74	83	Pond. P. Horan	20	P
75	68	Springy shores		D 10
75	70	Three pools. Gen. Lloyd Bryce	100	D 5
75	73	Pond. J. Sherrard		Special
75	74	Torrential Glen Brook		"
75	80	Pond. Thorn Davis	20	P
75	81	Pond J. H. Van Cott	50	P

H.	V.		Area.	Treatment.
76	68	Springy shores		D 10
76	69	Bryant Place Ponds and others		P
76	71	Pond. C. F. Mackay	25	P
76	78	Pond. Fred. Oakey	75	D 2
76	79	" Charles Simonson	75	D 1
76	79	" " "	50	P
76	82	Pond. J. H. McQueen	10	P
76	82	Two ponds. William Titus	150	P
76	83	Pond. P. Horan	15	P
77	68	Roslyn marsh and streams entering		Special.
77	70	Ponds of C. F. Mackay		"
77	74	Pond of W. C. Whitney		Being filled
77	78	Pond. E. D. Morgan	150	D 10
78	69	Three Roslyn ponds, marsh and stream		Special.
78	70	Pools of C. F. Mackay		"
78	72	Pond of " " "	50	P

The total approximate cost of the above work is found at the end of the Detailed Engineering Report.

[Signed] HENRY CLAY WEEKS.

Bayside, L. I., N. Y. City,
December, 1901.

An Account of the Work of Mosquito Extermination on Center Island, Oyster Bay, L. I., during 1901, by Henry Clay Weeks.

THE CENTER ISLAND WORK.

The work on Center Island, under the direction of the writer, which was the preliminary skirmish in the present larger campaign, was begun in January, 1901, by a survey being made of the largest area requiring treatment, viz.: Inner and Outer Great Meadow, which stretches about midway in the length of the island, from its east side to within about 400 feet of its full width. The entire catchment was found to be 202 acres, though the marsh itself was only about seventy-five acres. These points were necessary to know, so that on the one hand the proposed drainage ditches should not be too large, and thus entail the unnecessary handling of too much soil, nor on the other hand that they should be too small to effectively keep heavy storms from overflowing them onto the marshes. An attempt to drain the inner meadow was made several years ago, but the ditches were too small to be effective. A causeway also had been built across the narrow space between the two marshes, giving them the shape of the figure 8, and a pipe with automatic gate had been placed under same, but the pipe was too small for the catchment, and was too high to take off all the inner water. A windmill was erected to aid, but again this was too small and too uncertain of movement. The gate, not being screened, also became inoperative, and allowed tidewater to enter, where it was largely held behind the causeway. Thus the inner area became saturated with water, from the above mentioned causes, and the marsh not having entirely grown over, many marsh pools existed, all making conditions that rendered this a famous breeding place.

The new plan was to carry the water from the inner ditches through the causeway eastward and empty it, together with the catch of the outer meadow, into the bay. But this plan failed, not having the unanimous co-operation

of owners, and so the scheme for the outer meadow had to be entirely changed. The costly alternative was attempted of closing the creek several hundred feet from its mouth, and necessarily at a point where the creek was 106 feet wide, instead of fifteen feet at the point first proposed.

There was no firm found which desired to undertake a contract along untried lines of work at any reasonable figures, hence the work was undertaken directly. It was hoped it might be done otherwise than by hand, but this was not found possible. A squad of Italians with mattocks spades and chisels for cutting the tough sod, and with pumps, barrows and other tools, was worked for some weeks in the field, often in mud to the tops of their boots, and often in a stench from decaying vegetable and mollusk life that was nearly overpowering. The ditches in the inner meadow were first commenced, using material from same to fill all marsh pools and creeks, or, if not needed for that purpose, it was wheeled back to the edge of the uplands and graded so as to leave no water to collect behind it. The plan was in all cases to force the water outward. On account of the great length of the longest ditch a descent of only one inch in sixty feet was all that could be obtained, but by using care even this slight grade took the water almost entirely from the ditches and left none for breeding.

In the latter part of April some of the places that it was not found possible to fill or drain in time to prevent breeding were found alive with larvae, small pools in this inner meadow looking as if filled with moving black water. Now came the necessity of quickly using the temporary remedy, viz. : fuel oil, which was applied to all such places through the island. To one not knowing the efficacy of this remedy, the sight of the enemy in countless myriads would have been very discouraging. But within a few hours not a live larvae would be found ; and where any did get to wing, their breeding place was found nearby in some little point, possibly not larger than a hand, overlooked in spraying, showing two things—that they do not fly long distances from their breeding place, as well as the need of thorough work in filling or petrolizing. (Major Ross—one who has been most active in the question of mosquito extermination, and who is now on his fifth tour to Africa in that interest—says that

one of his positive conclusions is that "mosquitoes are incapable of flight over great distances.")

As there were no springs along the border of the uplands, and the watershed was relatively small, it was not considered necessary to run any ditches along the edge of the marsh. Some old ones here, however, were reopened. Where the uplands are springy, or there is an extended watershed, this outer ditching is very necessary.

A main open ditch was excavated, and lateral ditches, as necessary, were run into that. The result was that there was no breeding at the inner marsh, and one could walk through it during the season and not raise a mosquito, where formerly it was impossible to enter, and very uncomfortable to man or beast even to pass along its borders.

The next most difficult points to treat were the shore ponds, by which special name is designated those places alongshore whose bed usually is but little below high tide, where, by the action of the sea, a barrier is raised and the water within is confined, becoming brackish by extra high tides overflowing the barrier, and by rainfalls. There were several of these shore ponds, and they, too, were early alive with larvae, and required frequent watching, as they were not, the first season, fully engineered. With them the plan, for the time, was to run them out to sea, which was often done for hours together, thus carrying off myriads of larvae. The channel which had been made for this purpose was then closed temporarily after a few tides had well washed the beds. This process was repeated about monthly. In a very bad one of these ponds after this treatment, a person could walk throughout the bed and through the adjacent woods and not raise a mosquito, where before they were intolerable. In the finish of the work for such points an automatic tide-gate should be set at proper level, and by tile drains these places, generally valuable for celery and other crops, should be dried off and breeding places thus abolished.

The approximate estimate for the Center Island work was made before surveys had been made, and this, with other reasons, made the amount insufficient to complete the work. For instance, the spring was wet beyond record, and this, with the breakage of the windmill and old tide-gate, kept the men working in deep water at a great disadvantage and loss. Then, by the change rendered necessary in the plan

for the outer Great Meadow (as before referred to) a large outlay, not counted on, was necessary. In considering all these points it was judged prudent, in order to test the plans of relief, that most of the situations should be treated temporarily rather than attempt to finish a few and leave breeding to go on in the remaining ones. The work done, as far as it went, is all necessary in the final treatment. For example, a dike 750 feet long was raised along the shore facing the largest shore pond. A few dollars for a sluice and gate would complete all drainage necessary to prevent breeding; not, however, for cultivation. Another dike, 1,664 feet long, was raised in front of Outer Great Meadow, in both cases using the sand of the shore in construction, as a crest had already been raised by sea and wind about three feet above highest tides. There were placed beneath these dikes logs, found along shore, as far as they would extend. It is the purpose to strengthen them against extraordinary tides by shore stones placed along their base and by transplanting into the face the valuable beach-grass (*Ammophila araneria*) here found in abundance and which is used elsewhere to form sea-resisting beaches.

Where the dike leaves the shore and runs across the salt marsh, an inner ditch (used to hold water between tides) was dug and its material used to form the dike. The sod from it was cut into sections and set on the face of the dike to break the force of the tides. This ditch was kept well back from the dike so as to prevent muskrats burrowing through and making an inlet for the outer water. The section of this dike was made of a form to resist the strongest tides, as would be necessary if the Outer Great Meadow is to be subdued and cropped.

On account of the deficit in the fund the water was not successfully shut off the outer meadow, though an attempt was made. But after an examination by those competent to judge, it is acknowledged that the amount of work accomplished for the outlay was very large, although such outlay included quite an extensive outfit.

As before stated, fuel oil was used as a temporary expedient, where the permanent remedy, drainage, could not be completed. The petrolier made only five complete tours of the island. Other partial ones were made, as needed, at particular points. He used about five barrels only, and,

judging from what work has been completed, there will not be needed more than about two barrels next year, provided the unfinished work is completed early in the season. (See Appendix III.)

To use more oil than is found necessary is only a waste, and raises an objection to an efficient and harmless remedy. It is not necessary to consider the depth of a pond, but only its superfices, for it is the surface film that does the work. The rule (see Dr. Howard's new book, "Mosquitoes") is an ounce to fifteen square feet, or say a barrel to two acres.

Eight oil stations were established, and at these the petrolier obtained his supply for the various sections. Once in three to four weeks is as often as was found necessary to petrolize the island as a whole, but examinations for larvae were advisable oftener in certain places—where, for instance, a pond has dried up and shortly thereafter a storm comes. In such a case the larvae, apparently destroyed, revive, and thus have several days' start in life.

The preliminary report of the writer, dated October, 1900, had said of Center Island: "This being a tight little island by itself, could be treated independently and great relief be obtained. It is not meant it could be freed from mosquitoes without co-operation at adjacent points on the mainland, for their brood would be borne by a favorable wind a mile or so across water intervening."

From this it will be seen that no positive assurance of absolute relief was held out, and yet, on the strength of the encouragement given, a fund was raised by the residents boldly to make the test of the plans proposed. It was probably the first test to be made in this country, if not in the world, simply for the betterment of conditions in a large territory by community action.

While there were some favorable conditions for a trial, there were many unfavorable. Of the favorable, was the peninsular situation, the interest of the comparatively few people in the movement (the fewer the better for obtaining unanimous action), and the *carte blanche* given the engineer.

Of the unfavorable may be mentioned the fact that this was pre-eminently a mosquito year. An unapproached rainfall in April and May, followed by stretches of heat beyond record, the sodden condition of the land, the lack of entire

co-operation of owners, the numerous shore ponds (more than elsewhere within many miles), and the proximity of the famous Mill Neck section, with a narrow stretch of land connecting—these are among the many reasons why the highest results were not possible. And yet, with the balance of the conditions heavily against success, it is a fact that the island was almost entirely free from the pests. On the 16th of July, after a number of days of steady wind from the Mill Neck section, a few were borne thither but stayed only a short time. An exceedingly small number, relatively, were bred on the island, and those almost entirely on two places where access was not afforded for work. One point where cows tracked in the mud of their pasture near a pond was alive with larvae. These spread to closely adjacent points only, showing that they do not move far from their birthplace. Other parts of the island, some distance from those places not treated, may be said to have been free. Persons at the club house and residences, who had never been able to sit on the piazzas in the evening heretofore, reported that they did so without trouble this season.

The exceptional places were so small that the movement, notwithstanding them, was characterized as a success throughout the island.

These results are not claimed as being attained from any new theories or practice, but simply as the sure outcome of the insistence of well-known principles of engineering and of insect destruction.

[Signed] HENRY CLAY WEEKS.

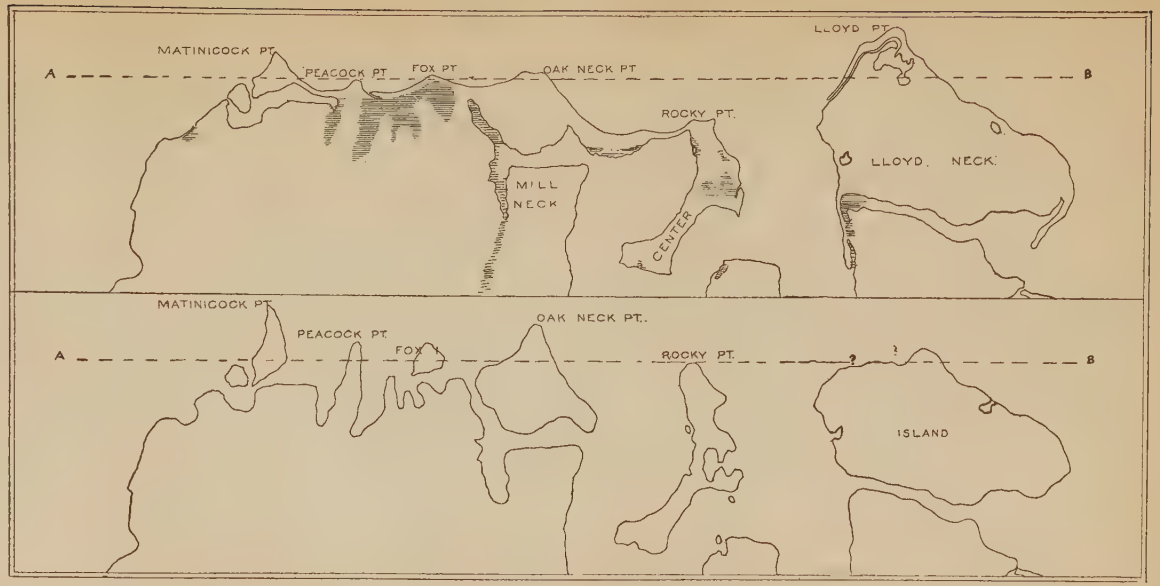
Bayside, L. I., N. Y. City,
December, 1901.

APPENDICES.

Appendix I.

ON FROST CREEK VLEYS.

As to the stones, which are quite abundant in the bed of the creek and all about the point of land which juts out between Mr. Guthrie's and Mr. Cravath's marshes, they lie there an almost hidden—universally unnoted confirmation of a geological fact. The outer beach, which now stretches unbroken from Bayville road to Peacock Point, about one and a half miles, once evidently did not exist. The materials which now largely form this beach were once a part of the promontories at Fox Island Point, Oak Point, and probably distant Center Island Point. These points once were as far seaward all along this shore as the rocks now extend, which are bare at low tide, and these rocks are all that remain at the original site, the detritus being carried westward to build beaches there. Fox Island, having once been an island in fact, has had its easterly and westerly ends gradually extended by this sea constructive process. Before this, and at a remote period, the sea waves dashed direct on the points of land jutting out between the present Frost Creek vleys. The marshes here have only formed comparatively rapidly since the perfection of the bar. The boulders in the present bed of the creek, as referred to in report, are those which were cut out of the promontory once there by direct detrital action before Fox Island had been extended that far westerly; the bar has covered over the area where the promontory once projected, and Fox Island soil has helped build up the bar down to the mouth of Frost Creek, which has gradually moved westward to Peacock Point, and unless action is taken to prevent will encroach upon that point. The boulders in the creek at the Guthrie bridge are at their original position. The point, probably once two hundred feet farther north, would be revealed, as these changes sometimes are, by excavation. One silent witness only of any size remains off the next point (Mr. Cravath's) to show that once the direct waters cut it out of this less elevated point. It is now embedded deeply in the marsh, about fifteen feet from the present uplands. The many boulders at the outlet of Frost Creek indicate the detrition at Peacock Point, which was once much farther east. (See sketch of ancient shore lines.) W.



Sketch showing the results of the detrital action as well as the results of the constructive action of the sea in building beaches and bars and the formation of marsh areas within such constructions—resulting in the most prolific breeding grounds of the section. See Appendix I.

Appendix II.

ON OPERATIONS IN OTHER PARTS OF THE COUNTRY.

The following is from the Honorable The Mayor of Winchester, Va., where a very successful test was made under his leadership during 1900, even without penalty for non-compliance :

WINCHESTER, VA., December 10, 1901.

DEAR SIR :

Yours of the 7th instant at hand. The results of the past year's operations against the mosquitoes were even more gratifying than were those of the previous year. Two causes operated to this end. In the first place, we enjoyed the benefit of the work of the first year; and, in the second place, while the first year's operations were wholly left to individual and voluntary action, those of the second year were conducted under the provisions of a law, with a penalty attached for disobedience, and under the immediate supervision of an officer appointed for the purpose of making constant inspection to see that the law was complied with. I believe that the most skeptical of the objectors this year yielded to the logic of a benefit so evident and so extensive as to leave them no ground for grumbling.

For the first time in six or seven years (since mosquitoes made themselves felt here) I wholly discarded mosquito nets in my house, and this was almost universally done during the past summer, although here and there peculiar local causes, or a disregard of the law, which could not be detected, enabled the little "buzzer" to carry on a sort of guerilla warfare. I propose to renew the fight in the early spring, and to keep it up until there is an unconditional surrender.

Yours truly,

R. T. BARTON.

The following shows what may be accomplished by a few workers, expending little means or effort:

RICHMOND HILL, L. I., December 16, 1901.

DEAR SIR :

Your letter asking for further particulars of the work for exterminating the mosquito in Richmond Hill, L. I., an account of which appeared in "Good Housekeeping" for May, 1901, is at hand. The article you mention contains full particulars of the kind of work done by the Civics Committee, both for this season and last season.

We, the Committee, had planned to extend the work this season to take under our jurisdiction all stray pools, pest-holes, and other gathering places for water, but being unable to raise the necessary funds to so extend our "sphere of influence," we were obliged to keep within the bounds designated in the article describing last year's work, to which I would refer you for the information you desire in making up your report.

This year, as last year, the Committee took charge of the thirty-eight public catch-basins. Beginning the 12th of April, one pint of kerosene was put into each catch-basin once every week during the Spring and Summer. The last distribution was made October 11th. The Committee also called the attention of the householders to the necessity of regular application of kerosene to the cesspools in the back yards in order to make effectual the work of the Committee.

In spite of our limited financial resources, and the primitive appliances for carrying on the work, quite a wonderful and unexpected success has followed what would seem, no doubt, to the Center Island experts, very simple and inadequate means.

Before the kerosene treatment was begun, Richmond Hill was notorious, even on Long Island, for its swarms of mosquitoes, which were ever present with us during all hours of daylight and darkness, from early spring, and continuing in houses until after Christmas. I remember the fall of 1899 I had to keep the mosquito nets up over the beds until after Christmas, and that season and the years before it was almost impossible to work among my flowers at any time of day, owing to the swarms of mosquitoes. People passing on the streets were obliged to keep up lively gymnastics to disperse the swarms of mosquitoes settling on all portions of one's anatomy.

Last year we were quite free from the pests—surprisingly so—compared with former years, and this year we had fewer still, and none at all during the fall, which is usually their hunting season.

If there is any further information I can give I shall be glad to give it, and shall be most happy to cooperate in any possible way with any movement looking to the extension of this work; for I am persuaded from the good effects following our very primitive methods and, to a certain extent, inadequate appliances, that the total extermination of the mosquito on Long Island is only a question of intelligent and continued cooperation between the authorities and associations of enlightened individuals directed by scientific experts.

I was very much interested last summer by a newspaper notice of the work on Center Island, and I should like to have a fuller account of it. Can you put me in the way of getting it?

Trusting this may give you the data you desire, and may tend to further developments along this line of work, I am,

Sincerely yours,

(Mrs.) Martha Holladay Claghorn,

Chairman of Civics Committee Twentieth Century Club,
Richmond Hill, L. I.

The following is from the Health Officer of South Orange, N. J.:

January 2, 1902.

Dear Sir.

In regard to the extermination of mosquitoes in this district, the work was conducted under my direction, and I take pleasure in forwarding you herewith a copy of my report to the Village Improvement Society, which I trust will provide you with such information as you seek in regard to the work which has already been done in this neighborhood. From observation and inquiry I found malarial diseases during the last season not so marked—but few cases coming under observation, and those of a mild type.

Yours very respectfully,

W. W. Heberton, M. D.,
Health Inspector.

Extract from Report.

* * * * * * * * *

The treatment for the extermination of the mosquito was commenced this season after the first crop was upon us, yet comparative results have been satisfactory. In the early part of the treatment, when one person would have his premises cared for, his neighbor would furnish fertile breeding grounds. Near the village boundary lines in adjoining districts were pools untreated, and the results here were not so satisfactory.

About culverts, when during Summer evenings the mosquitoes flew in clouds about one's head, they disappeared.

During the months of September and October, when cool nights drive the mosquito indoors, they have not been as troublesome as in other years, except to those who reply to questions, "One mosquito is as bad as an hundred, and will keep me awake all night."

The experiment has been a success, and another year will capture the one troublesome mosquito.

Respectfully submitted,

(Signed) W. W. Heberton.

[Copy]

Appendix III.

ON THE CENTER ISLAND WORK, FROM MR. COLGATE HOYT, TREASURER OF THE COMMITTEE.

January 17, 1902.

PAUL D. CRAVATH, ESQ.,
Locust Valley, Long Island, N. Y.

MY DEAR MR. CRAVATH:—

As a resident of Center Island, and being deeply interested in the work of exterminating mosquitoes from the north shore of Long Island, I have read with great interest Mr. Henry C. Weeks' report to you on what was accomplished on Center Island during the season of 1901, and I most heartily endorse all Mr. Weeks has said. I do not think, however, that either he or I have as yet solved the problem of the most economical, combined with the most successful, way of draining the Outer Great Meadow on Center Island. Owing to the unusual high tides and other conditions, the time and money expended there did not bring about the results we all so much wanted; and I personally question as to whether this can be successfully accomplished, except by the expenditure of very much more money than we had heretofore estimated.

Mr. Weeks' work in ditching and draining the Inner Meadow, in filling low places, and in thoroughly petrolizing ponds and stagnant pools, and eliminating, as far as possible, other sources of trouble, was in every way successful and gratifying ; and although, as he says, the season of 1901 was unusually favorable to the breeding of these pests, notwithstanding this, Center Island was practically entirely relieved from mosquitoes, and for the first time, at almost all hours of the day and evening, we were able to enjoy the use of our piazzas and lawns without the annoyance of these pests.

The results achieved by the use of fuel petroleum were simply remarkable, and I was astonished to find how little it was necessary to use to accomplish the results desired, and how promptly and perfectly this petroleum destroyed the larvae, which at times were found so abundant.

I most heartily commend you and your associates in the work of fighting the mosquito along the North Shore of Long Island ; and from the results we attained last season on Center Island I am confident that by intelligent and persistent work the mosquito can be entirely and permanently annihilated from our beautiful shore.

Yours most truly,

COLGATE HOYT.

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